ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 62. No. 25. 220 Broadway, New York, December 16, 1909.

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Suspension Bridge of 600-Ft. Span Across The Culebra Cut of the Panama Canal.

By A. S. ZINN,* M. Am. Soc. C. E.

In July, 1908, the Superintendent of Water Service, who has charge of the laying of all water and compressed-air pipes used in the operation of excavation equipment on the Central Division of the Panama Canal, reported that on account of the increasing depth of Culebra Cut and the constant shifting of tracks to accommodate the 47 steam shovels it was necessary to frequently cut and change the 8-in. compressed-air pipe line and the 6-in. water main crossing to the east side of the Culebra Cut for operating the drills and steam shovels along that side for a distance of seven miles. This necessary change of main pipe lines proved very expensive. It was estimated that if they could be placed where they could remain undisturbed until the completion of the Cut, a saving of about $60,000 could be made in five years.

A preliminary estimate showed that a suspension bridge to carry the pipe lines could be constructed at a reasonable cost, and that it would be economy to build it. Therefore, in February, 1909, it was decided to build a temporary suspension bridge of 600 ft. span, with a roadway wide enough to allow the passing of a two-horse wagon with sufficient room each side for the pipe lines. The Resident Engineer was requested to furnish plans and take charge of the construction.

On account of not being able to find any literature on the designing of an ordinary suspension bridge of this type and dimensions, and as it was desirable to use in the construction as far as possible such material as was on the Isthmus at that time, it was necessary to be original in designing all the details. The purpose of presenting here the plans and a statement of the method of designing and erecting is the hope that it may be of some help or suggest a better design to other engineers called on to design and erect a similar bridge.

It was found that there was on hand the material necessary except the proper sized cables, turnbuckles and bridge sockets. These were ordered from the States and the construction started March 11, 1909. The only available material that could be used in the 60-ft. towers to stand six years without decaying or being destroyed by the wood ants was 6 × 12-in. and 5 × 10-in. creosoted pine in 16-ft. lengths; so the towers were designed to use this material by bolting it together as per plan Fig. 6.

It was desired that the bridge be as rigid as possible. The following plans were adopted: The stringers were made up of 3 × 12-in. by 12-ft. pieces and connected by 3 × 12-in. by 4-ft. packing blocks, bolted together at each suspender rod, making a continuous stringer at each side for the full length of the 600-ft. span. Thus the stringer was enabled to assist the trusses in distributing concentrated loads over more than one pair of suspender rods. The truss system on the sides was made up of 4 × 6-in. and 6 × 6-in. pieces, braced and fastened to the floor sills as shown by Fig. 3. The floor sills were made of 8 × 10-in. creosoted pine in 16-ft. lengths. To prevent the suspender rods cutting into them when subjected to heavy loading, cast-iron saddles were used at bottom as per Fig. 7. Creosoted planking 3 ins. thick was used for the flooring; it was nailed to the stringers with 20d. wire nails. Three lines of 2 × 4-in. strips were nailed to the inside of the trusses as guard-railing.

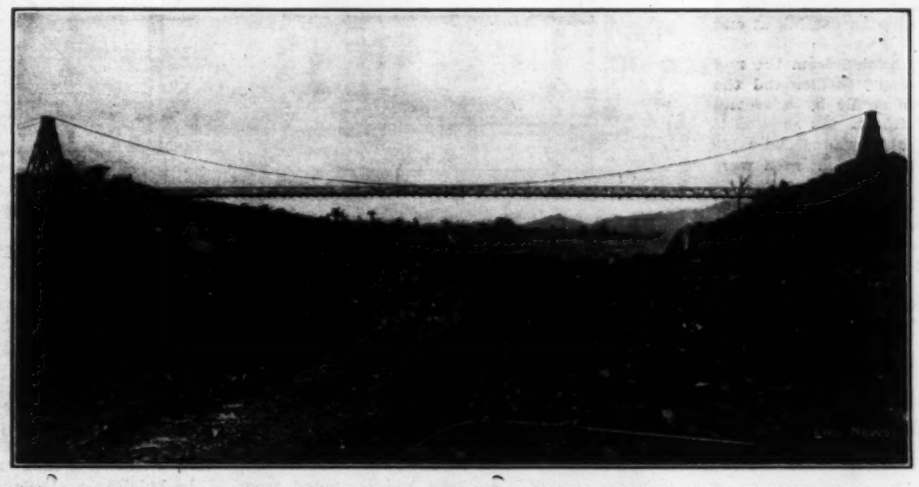

FIG. 1. HIGHWAY SUSPENSION BRIDGE ACROSS PANAMA CANAL CUT AT EMPIRE, C. Z.; SPAN 600 FT.

The 8-in. compressed-air pipe was laid on the floor next to the hanger rods on one side of the roadway, and the 6-in. water pipe on the other side. At each end of the bridge these pipe lines were equipped with expansion joints to take up variations of length due to changes in temperature. And as these pipe lines are continuous and firmly anchored at each end, they also aid in making the bridge more rigid.

At each side of bridge are four ¾-in. cable side guys to prevent swinging during a windstorm, and beneath the bridge at each end are four vertical ¾-in. cable guys to prevent undulations or lifting of floor by a strong wind.

The cables supporting the span are two 2¾-in. cables on each side. The two pairs of cables, 8 ft. 8 ins. c. to c., are connected at six places by angle irons so that one pair cannot swing without the other.

After the span was in place, it was lined to a true curve by means of the turnbuckles on the 1-in. suspender rods, and the king rods at the center of each 12-ft. panel truss were firmly tightened by the nut at the top of king rod. Each end of the trusses is fastened to the tower posts.

After all the connections were made, it was found that the bridge was practically rigid. The only perceptible undulation is caused when a team crosses with a load of crushed rock weighing in all about three tons, making a total dead and live load of about 720 lbs. per lin. ft.

A breaking test was made of one of the 1-in. hanger rods with turnbuckle attachment, and it broke at the upper ring where welded, with a weight of 31,040 lbs. A pair of these hanger rods is used every 12 ft., so that their strength is equivalent to a breaking load of 5,173 lbs. per lin. ft. of span. Each of the four 2¾-in. main cables has a breaking strain of 310 tons, which is equivalent to a load of 4,300 lbs. per lin. ft. of span.

In calculating the lengths of the suspender rods it was assumed that when the bridge received its full dead-load the cables would hang in the curve of a parabola. The middle ordinate was assumed as one-twelfth the span, or 50 ft. The floor line also was assumed parabolic, with 5-ft. camber. It was then necessary to calculate the ordinates to find the distance between the two parabolas at each panel-point. While it was found that the cables do not hang mathematically on the curve of a parabola, yet they are so close to it that the floor could be adjusted to the calculated curve by means of the turnbuckles of the suspender rods. The main cables were adjusted on the suspender rods. The main cables were adjusted to the desired height at center of span by means of the 3-ft. screw takeup on the open bridge sockets at each anchorage.

The main cables are each 870 ft. in length. They are made of galvanized crucible steel 2¾ ins. in diameter, weighing 12.7 lbs. per ft., having a tensile strength of 170,000 lbs. per sq. in. Each cable is fastened at each end to a casting weighing 700 lbs. to which are connected the open bridge sockets, so that each cable to be handled weighs 5.6 tons, and it was a question as to the

*Resident Engineer, Isthmian Canal Commission, Empire, C. Z., Isthmus of Panama.

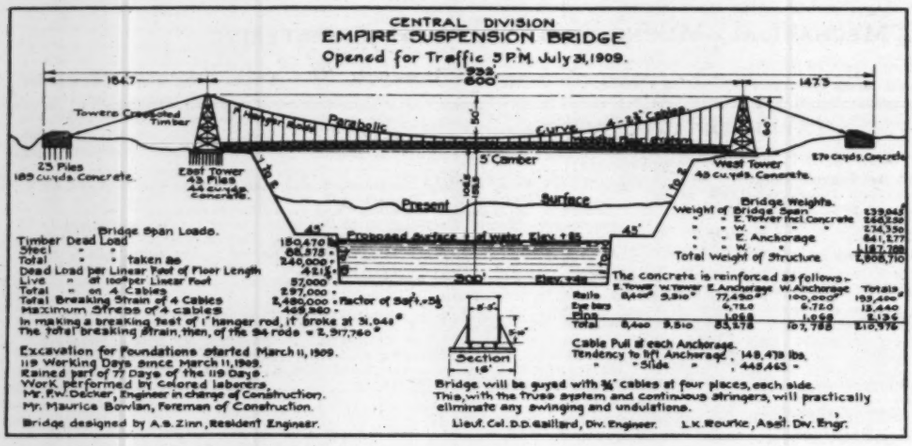
CENTRAL DIVISION
EMPIRE SUSPENSION BRIDGE
Opened for Traffic 5 P.M. July 31, 1909.
Towers Creosoted Timber
Parabolic Curve
4-2¾" Cables
23 Piles 189 cu.yds. Concrete.
East Tower 43 Piles 44 cu.yds. Concrete.
West Tower 48 cu.yds. Concrete.
270 cu.yds. Concrete
5' Camber
Present Surface
Proposed Surface
Elev. 785
Bridge Span Loads.
Timber Dead Load 150,470
Steel " " 88,878 "
Total " " taken as 240,000 "
Dead Load per Linear Foot of Floor Length 421 lbs.
Live " " " " " 57,000 "
Total " on 4 Cables 297,000 "
Total Breaking Strain of 4 Cables 5,480,000 " Factor of Safety = 3½
Maximum Stress of 4 cables 468,980 "
In making a breaking test of 1" hanger rod, it broke at 31,948 "
The total breaking strain, then, of the 34 rods = 2,917,760 "
Excavation for Foundations started March 11, 1909.
119 Working Days since March 11, 1909.
Rained part of 77 Days of the 119 Days.
Work performed by Colored laborers.
Mr. R.W. Decker, Engineer in charge of Construction.
Mr. Maurice Bowlan, Foreman of Construction.
Bridge designed by A.S. Zinn, Resident Engineer.
Bridge Weights.
Weight of Bridge Span 339,048
" " E. Tower incl. Concrete 248,250
" " W. " " 234,350
" " E. Anchorage 841,277
" " W. " 1,187,388
Total Weight of Structure 2,808,710
The concrete is reinforced as follows:-
Cable Pull at each Anchorage.
Tendency to lift Anchorage 148,478 lbs.
" Slide " 448,463 "
Section
Bridge will be guyed with ¾" cables at four places, each side. This, with the truss system and continuous stringers, will practically eliminate any swinging and undulations.
Lieut. Col. D.D. Gaillard, Div. Engineer. L.K. Rourke, Asst. Div. Engr.

FIG. 2. OUTLINE DRAWING OF EMPIRE SUSPENSION BRIDGE.

best method of stretching them over the towers and fastening them to the anchorages.

The arrangement used is shown by the sketch Fig. 9. Anchor bolts 1-in. in diameter were imbedded in the top of the concrete at each anchorage. At the west anchorage was set the cable reel, anchored to these bolts. A brake lever was fitted to the reel for controlling the unwinding. At the east anchorage a 30-HP. hoisting engine was set on 12 × 12-in. timbers anchored to the bolts. The cast-iron cable saddles on the towers were spiked to prevent sliding while the cables were being drawn across, and their grooves were greased to allow the cables to slide over more easily. Cross frames of 6 × 12-in. timbers were placed 7 ft. above the saddles on which to fasten rope tackle for pulling the heaving casting at end of cables over the saddles.

The end of the cable was hauled from the reel up to the west tower by hand tackle, and the casting was lifted over the saddle by a second tackle hitched to the cross frame. As soon as it was over the tower its weight unwound the cable until it reached the ground, and eight men were needed on the brake lever of the reel to keep it from running away. When the end reached the ground at "B," the hauling line was attached and the cable pulled across the Cut by the hoisting engine to within about ten feet of the top of East tower. The casting was then lifted clear of saddle with smaller blocks as at West tower, until it reached point "C." It was then drawn down to the socket rods "D" by the engine and the heavy set of blocks. Before the cable was entirely unwound, tackle was fastened to the cable between the west tower and reel by means of iron clamps, and handled carefully by 20 men to prevent the cable from getting away when entirely unwound. As soon as it was off the reel, the reel was rolled out of the way and the casting fastened to the sockets at the west anchorage, and then at the east anchorage.

The same procedure was gone through with the other three cables. They were then brought to final position by about three men at each end tightening up the nuts on the sockets by means of a chain wrench with a 5-ft. handle.

As will be noted from the drawings, throughout the main span there is a clear space of 1-in. between the two cables of each pair. The 1-in. U-bolts from which the suspenders are hung go through this space. They are fastened to castings clamped to the cables by ½-in bolts. It was thought by some that the cables would not hang accurately enough in the same curve to allow the attachment of these castings, but no trouble of the kind was experienced.

The clamps and suspenders were placed after the cables were in their final position. In order to fasten them and allow the men to move back and forth, 1-in. ropes were fastened to the cables near each panel point (see photograph Fig. 10), carrying 4 × 6-in. timbers placed across and below the cables; 3 × 12-in. plank were laid on these beams along the inside line of each pair of cables, furnishing a place for the men to walk. The suspender rods with their stirrups were then attached, and the sills placed through the stirrups. Temporary planks laid on the sills furnished a walk for starting the floor system.

The bridge was completed in 119 days, although during this time it rained part of 77 days. Local conditions made it difficult to deliver material for the construction of the reinforced concrete anchorages. The entire bridge was built by negro laborers who were inexperienced in performing this class of work. Besides, it was necessary to avoid blocking traffic in the Cut while stretching the cables.

The total cost of the bridge was $22,000, which is much more than a similar structure would cost in the States under more favorable conditions in regard to material, labor and climate. That it was a good investment has already been demonstrated, as the bridge not only furnishes a permanent crossing for the pipe lines, but is used extensively by men and teams to reach the construction work on the wagon roads being built east of the canal, as well as by hundreds of natives living east of the canal to deliver farm products to the residents of Empire. It also provides a crossing for the quick delivery of dynamite for blasting along the west side of the Cut at that point.

Experience with this bridge shows that the actual lengthening of the four 2¾-in. cables with a dead-load of 421 lbs. per lin. ft. is 2½ ins. per 100 ft. The deflection with full dead-load is 14 ins., a trifle less than calculated.

In building a similar bridge it is recommended that in place of having the seven pairs of suspender rods at center of span without turnbuckles, all have turnbuckles, and that the take-up instead of 6 ins. be made 12 ins., to allow more room for adjustment.

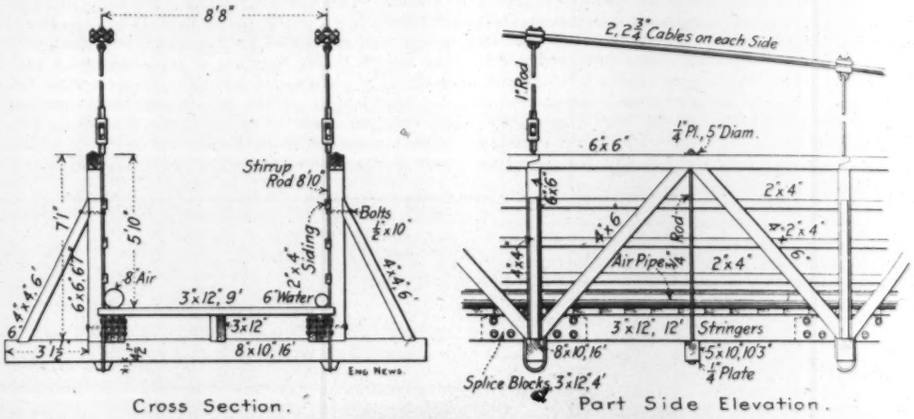

FIG. 3. CROSS-SECTION OF EMPIRE SUSPENSION BRIDGE, AND ELEVATION OF TRUSS PANEL.

FIG. 4. WEST ANCHORAGE OF EMPIRE SUSPENSION BRIDGE DURING CONSTRUCTION.

(Shows method of setting anchorage eyebars accurately. Size of eyebars 6 × 1½ ins., 27 ft. 7½ ins. long c. to c. of eyes; two bars for each cable. The eyes at rear end engage a 5-in. steel pin 14 ft. long; eyes at cable end engage a 5¼-in. steel pin 26 ins. long holding the bridge sockets.)

THE PROTECTION OF STEEL BY CONCRETE.—In the construction of the Washington St. Tunnel at Boston, Mass., it became necessary to tear down a portion of the Haymarket Square station of the old subway built about ten years ago. This construction, described in Engineering News, May 30, 1895, consisted of steel columns and girders partially embedded in concrete. In order to get some record of the development of rust under such conditions, an assistant engineer in the recent reconstruction was detailed to observe all steel removed from the station and to note any deterioration of the metal from rust. The 1900 report of the Boston Transit Commission contains the following resumé:

About 200 columns, 70 beams and 150 knee-braces were removed and portions of numerous other steel members were exposed. Practically all of this steel was found to be substantially free from rust. Some rust was found on the bottom of a considerable number of rather large (¾ × 21 × 24-in.) base plates of columns. This rust was generally thin, but had local swellings, some of which were nearly ½-in. thick. It is presumed that the rust was caused or permitted by a slight settling or shrinking away of some of the finer portions of the concrete under said plates, leaving the latter resting on the coarser portions. The smaller base plates were practically free from rust.

Extracts from Papers Before the British Road Conference of 1909.

The International Road Conference held at Paris in 1908 was followed early in the present year by a British Conference. The latter was called by the County Councils' Association, and was joined in by numerous municipal and engineering societies, including the Association of

Fig. 5. East Anchorage Completed Ready For Attaching Cables.

(Foundation piles, 15 ft. penetration, extend up 3 to 4 ft. into concrete. Concrete reinforced with 60-lb. steel rail.)

Municipal and County Engineers and the Institution of Civil Engineers. Of the many papers on various phases of road construction, maintenance, legislation and statistics presented at the conference we have selected for partial presentation here a few showing greatest promise of interest to our readers.*

Wear and Tear of Roads.

By WM. NISBET BLAIR.†

[Most of the papers dealt with macadam rather than pavement proper, but we make citations from two which related to a portion of London and to Liverpool, respectively. Particular attention may be called to the experience with macadam in London, given by Mr. Blair.—Ed.]

The life of any pavement depends on the amount and composition of traffic, the concentration in definite lines, the gradient of the road, and the nature of adjoining pavements. It needs no proof to say that the greater the traffic the greater the wear. But there is more importance in the composition of the traffic than may at first appear; there is no class of town traffic so destructive to pavements as the horse omnibus, and the higher the proportion this forms of the total traffic so much the worse for the road. The regular stopping places of the omnibuses can be recognized by the state of the paving, more especially on wood paving. This is mostly due to the horses' feet, but partly also to the screwing of the wheels. It was found some years ago that at the West Strand Post-Office, yellow deal blocks wore down 4½ ins. in twelve months; this was replaced by jarrah, which wore 2¼ ins. in three years; but at this point there are from 300 to 400 omnibuses per hour stopping and starting. Heavy railway vans with two horses, usually traveling at trotting pace, are also very severe on roads. The existence of tramways or columns in the center of a road lead to the traffic assuming a constant position in a road, with consequent additional wear in that track, while the center may almost entirely escape. The gradient of a road increases the wear as it becomes steeper, and the downhill side is more quickly worn than the uphill. This is on account of the faster pace increasing the wearing effect of the horses' feet, as well as the crushing action of the wheels. The influence of adjoining pavements is principally in regard to dirt carried from them by passing wheels—for instance, off macadam or flint roads on to wood; this dirt itself exerting a grinding action under traffic, but it also necessitates sanding or graveling to remove the greasiness which results.

The cases in the accompanying table indicate the durability of different classes of pavement.

Similar particulars cannot be supplied for asphalt or creosoted wood paving, for both have only been laid about two years in the district dealt with.

Ordinary water-bound macadam is still used in streets of second-rate importance as regards traffic, and it is admittedly open to many objections; it rapidly wears into hollows, causing lodgment of water, too quickly for these to be individually repaired, and the recoating is necessarily frequent and expensive, but where all roadwork, including paving renewals, has to be met by the current rate and not by loan the general adoption of a more desirable pavement, and one less subject to complaint for one fault or another is impossible.

TAR MACADAM.—Short sections of road have been dealt with experimentally by other systems. A length of road was recoated with Guernsey macadam, and after being rolled hard and blinded with dry chippings it was tar sprayed during September of last year. There is a fairly heavy traffic over it, and it has never become solid; it is always working, and the tar has produced a greasy black mud in wet weather, much more objectionable than the ordinary macadam mud.

Another road was stripped and coated with 4 ins. of tarred slag macadam in November, 1907. It unfortunately happened that during the month the work was in hand it rained almost daily, and soaked the foundation

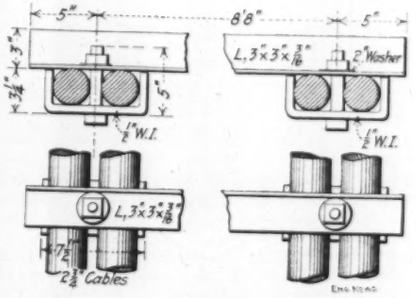

Fig. 6. Details of Stiffening Strut Between Cables.

of hardcore on clay, with the result that the surface of the tar-macadam worked loose under traffic in many places, and there has never been as regular and uniform a face as is desirable.

In another road, where the foundation was known to be bad, it was entirely removed, and a new hardcore foundation of broken York stone and other good material was rolled solid to a depth of about 18 ins. On this, tarred slag macadam 4 ins. deep was spread in two coats and well rolled in, July, 1908. This also has broken up in patches. The traffic is not large in point of numbers, but the vehicles are mostly heavy—such as coal and railway vans.

In July, 1908, another road was stripped, and the foundation found to be perfectly solid. It was covered with tar-macadam 4 ins. thick, the same material being used as in the last case. This has proved to remain quite solid, and no fault has been observed since it was laid. The traffic in this case is about the lightest possible, for there are really only the tradesmen's carts calling at the various houses to use it.

It has been observed that a greasy condition of surface occurs on all these cases of tar-macadam during damp weather, due to the fine grinding of quite a small quantity of mud under the wheel traffic, and this causes the horses to slip a good deal, especially when going downhill. To counteract this, coarse sharp sand is spread very lightly, and is effective until it also gets ground up, making more greasy mud. Washing is then resorted to, and that gives a very good result until passing traffic carries on dirt from adjoining roads, or produces mud from the road itself, and the cycle is repeated.

All these tar-macadam roads are much more slippery in time of frost than ordinary granite macadam, and constant attention for clearing off droppings and for sanding is required; but even then complaints are received, describing one side of a bridge as a dangerous gradient which was never regarded as having any inclination worth remark prior to the use of the tar-macadam.

In dry weather the foothold is excellent, and the silence of traffic is most noticeable, the removal of droppings is easily effected, and the reduced amount of dust is much appreciated. In many situations tar-macadam may prove a most suitable road surface, but it is still open to doubt as to whether it will carry heavy loads without disintegration.

*Many if not all the papers, together with discussions, were printed in the London "Surveyor" for May 7, 14, 21 and 28, June 4, 11 and 18, July 2 and 16, 1909. Our extracts are from the papers on the general subject of construction and maintenance, printed in the "Surveyor" of May 7 and (the last one only) June 18.

†Borough Engineer of St. Pancras [one of the boroughs composing the "administratric county of London."—Ed.]

DURABILITY OF VARIOUS KINDS OF PAVING MATERIAL, ST. PANCRAS BOROUGH, LONDON, ENGLAND.

Road.	Material.	Paved.	Removed.	No. of vehicles per hr. Total.	Horse buses.	Width.
Pancras-road	Mountsorrel setts*	July, 1892	Still good	521	..	32 ft.
Fortess-road	Enderby setts	Jan., 1896	Very good	223	..	33 ft.
Euston-road (by Midland Hotel)	Jarrah blocks	June, 1893	Oct., 1900	1,162	280	37 ft.
Euston-road (by Fitzroy-street)	Jarrah blocks	Mar., 1893	Aug., 1906	765	128	30 ft.
Euston-road (by Fitzroy-street)	Yellow deal blocks	Mar., 1893	Mar., 1899	765	128	30 ft.
Gray's Inn-road	Jarrah blocks	Dec., 1897	Still in use	731	60	About 35 ft.
Park-street	Jarrah blocks	June, 1893	Mar., 1907	239	..	27 ft.
Upper Woburn-place	Jarrah blocks	July, 1899	Still in use	461	39	26 ft. 9 in.
Gordon-square (west side)	Jarrah blocks	June, 1893	Still in use	Mostly cab traffic.		..

[*Stone blocks.—Ed.]

Notes on the Tonnage-Life and Wear of Stones in Road Surfaces.

By JOHN A. BRODIE,* Wh. Sch., M. Inst. C. E., M. I. Mech. E.

In Liverpool it has been customary to take occasional records of the numbers and classes of vehicles passing along the principal traffic streets, and to reduce these records to a standard of tons of traffic per yard width of carriageway per annum; and a great point would be gained for the more accurate comparisons of wear and costs of street and road surfaces if this standard—which has long been in use and found satisfactory—could be universally adopted in this country.

It is also important that, if possible, practical standards of wear should be arrived at for the materials which can now be obtained in almost uniform quality and condition from the best-known quarries and other sources of supply, and it appears likely that useful standard figures of wear based on actual results of tonnage-life over road surfaces could, with a little cooperation, soon be fixed for each such material in any one class of surface—say, for example, in the case of macadam—on the tonnage-life per yard of width for a given thickness of coating.

Where, owing to the conditions or amount of traffic, it is not necessary or convenient to completely coat a macadam road, useful comparisons could probably still be obtained by accumulating the cost per unit for maintenance until the cost of a complete coating had been reached, and adopting this period of tonnage as for a complete coating.

It is, of course, probable that such standards would require to be judiciously used, as it is hardly likely that the tonnage-life of a material on, say, 60,000 tons† per yard width per annum street would compare exactly with that of, say, a 5,000 tons per yd. per annum road, as, no doubt, the methods of maintenance, weather, climatic and other conditions would materially affect the results obtained.

The result of tests made in Liverpool has been to show that there is practically only one type of material economically possible for all classes of stone road surface in that district, and the splendid road materials coming from the Penmaenmawr and other quarries in Carnarvonshire have proved to be not only the best and most lasting, but at the same time happen also to be

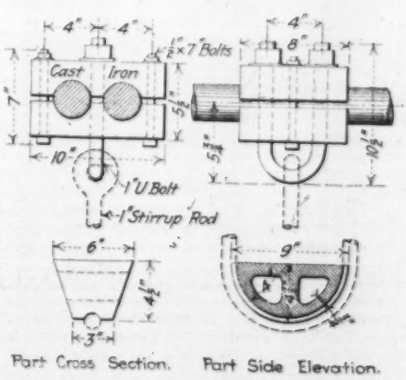

Fig. 7. Details of Suspender.

(Turnbuckles in all suspenders except 7 middle ones of each cable.)

the cheapest stone available for streets within cartage distance from the dock quay.

The same stone is used in the form of setts, accurately dressed to sizes, along the line of docks, and also in the form of macadam for streets of comparatively little traffic, and some interesting lessons may be learnt from its behavior and life under different conditions.

*City Engineer, Liverpool.

†It should be remembered that the tons here given are of 2,240 lbs.

STONE PAVING.—Taking heavy-traffic streets first, experience shows that accurately dressed setts, 6 ins. deep by 6 ins. to 8 ins. long by 4 ins. wide, laid on a sound concrete foundation at least 8 ins. deep, with a small sand bed between the underside of the sett and the concrete, the joints being thoroughly racked with hard shingle and afterwards grouted with a permanent pitch mixture, which prevents any movement in the stones, and renders the whole surface perfectly impervious to weather, give a life equal to at least 7,500,000 tons per yd. width, and under these conditions this life has often been exceeded.

It is at present impossible to say whether an equal tonnage-life can be obtained from the similar but shallower 4-in. class of construction in streets taking, say, 60,000 tons per yd. of width, as this would mean a life exceeding 100 years; but experience shows that the total average wear of the setts has been exceedingly small, and it is a fact that many such streets exist in Liverpool to-day having a life of from 25 to 30 years without requiring any important repairs during that time due to wear of the material.

ORDINARY MACADAM.—When the same quantity of stone is used in ordinary macadam laid 6 ins. to 7 ins. deep on a sound, hand-pitched foundation, experience shows that the tonnage-life of the surface before requiring to be recoated is enormously decreased, and instead of 7,500,000, a figure about 100,000 tons only, or about 75 times less than the result for setts previously given, has been obtained on a street of moderate traffic—a somewhat startling difference.

Of course, the two figures may be said to be hardly comparable, but they are so for all practicable purposes, and the broad fact remains that the surface of the macadam has—on the average—worn or been impounded down from 1 to 1½ ins., while the surface of the sett has not been worn more than from ½ to 8[illegible] on the average.

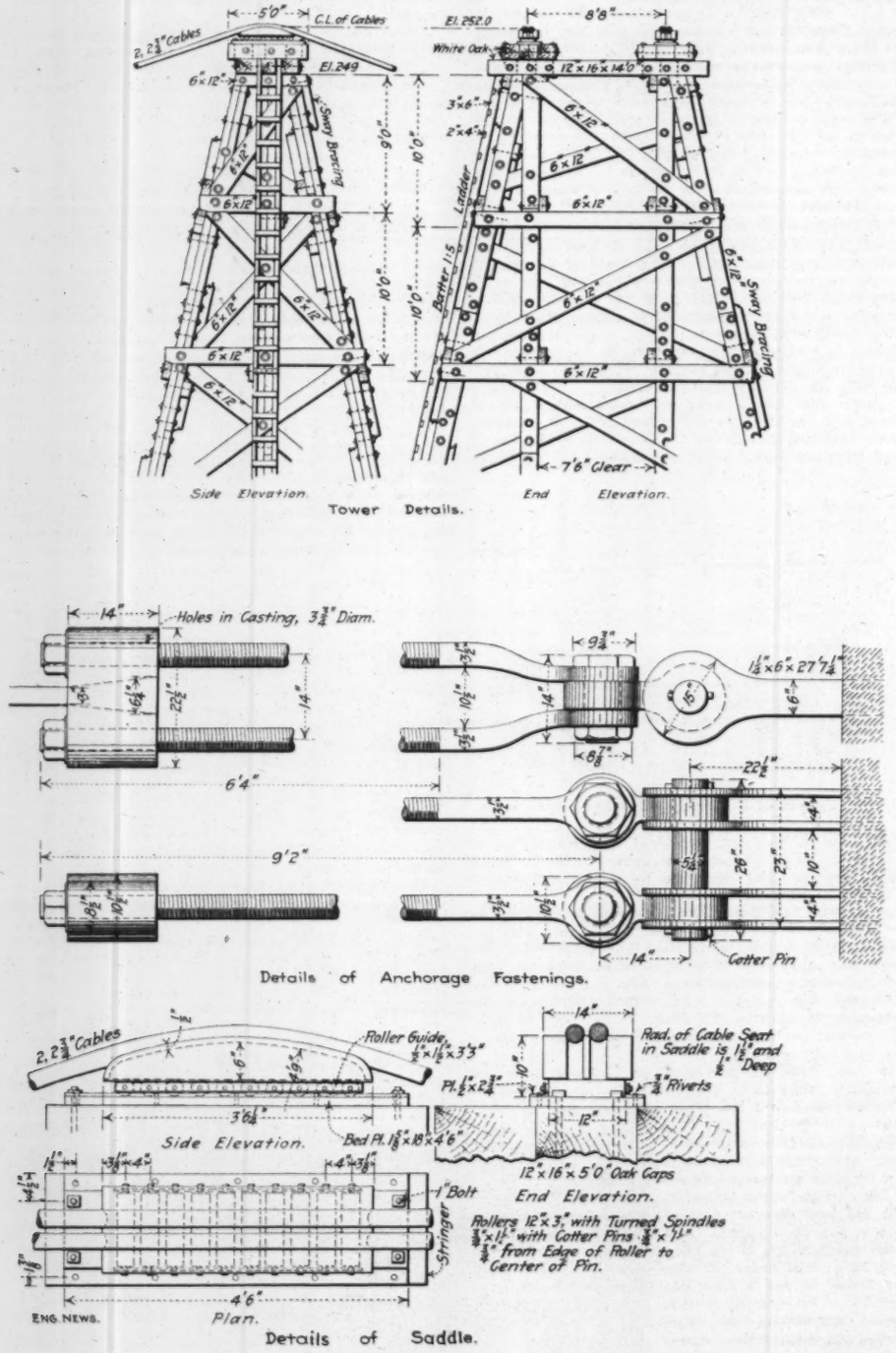

FIG. 8. DETAILS OF TOWER, SADDLE, AND FASTENING AT ANCHORAGE.

It would not be safe to assume that the traf[illegible] tonnage-life here given for macadam is the average [illegible] obtainable from this material in a macadam road, [illegible]t it is a genuine average life of a series of compl[illegible] coatings of 1½-in. material on a practically level mac[illegible]m street laid to a depth of about 6 ins. on an exc[illegible]t hand-pitched foundation carrying a considerable [illegible]ume of narrow rubber-tired vehicles, motor cars a[illegible] general light traffic, in which it has been customary [illegible] keep the surface in good order by completely rec[illegible]ng the whole width of the street as soon as the surfa[illegible] becomes generally unfit for comfortable use by bicycli[illegible]

PITCH [TAR] MACADAM.—Another interes[illegible] result has also been brought more clearly to light by these records of traffic tonnage. A portion of a mac[illegible]m road surface has been removed to a depth of 4½ ins. and replaced by an equal depth of ordinary macadam stone, laid in two layers spread in the ordinary way, and, after dry rolling, the interstices have been completely grouted or poured up with a permanent pitch and sand mixture, so that each stone is imbedded in or surrounded by the mixture, the whole being again rolled while still hot with a 10-ton roller until consolidated and rendered thoroughly impervious.

The results up to date show that when properly dealt with on these lines the life of the surface can be extended from 100,000 traffic tons to at least 750,000 traffic tons per yd. of width, or 7½ times the average life of the ordinary macadam under the same traffic conditions, though still, it will be observed, only one-tenth of the tonnage-life of the sett pavement street first referred to.

This improved result, while also remarkable, might almost be expected when it is borne in mind that embedded in such an elastic mixture the irregularly-shaped macadam stones are firmly held up to their work very much after the condition of stone setts, and not being allowed any appreciable movement, they are so prevented from wear by the rubbing and grinding action so harmful in ordinary macadam.

That this is the case is clearly shown by the section of a piece of this surface, the traffic on which has already exceeded 560,000 tons per yd. width, the stones in which have been washed clean by a spray of petrol. While the edges of the stones near the surface are somewhat rounded, the edges of all stones below the surface are as sharp as when originally laid, and this could not possibly be the case where there is any considerable amount of movement among the stones due to traffic.

The writer came to the conclusion that to obtain the best result with small stones it would be necessary to present a surface of each individual stone sufficiently strong in itself to take the weight of individual wheels without crushing, and at the same time held firmly, so that the abrading action common in macadam should, if possible, be avoided.

MACADAM CONCRETE BLOCKS.—His first step in this direction was the formation of concrete macadam blocks, in which the wearing surface consisted of selected macadam placed by hand on a true surface in a mold—wearing surface downwards—strong Portland concrete material being subsequently filled in and around the stone to a uniform total depth of about 4½ ins., and undoubtedly, when properly matured before laying, these blocks give excellent results as regards wear and quietness.

A sample block has been laid for five years in a street having a traffic tonnage of 25,000 tons per yd. width per annum, and it will be seen that though it has already exceeded the ordinary tonnage-life of a macadam surface there is no apparent wear on the stones, and it appears likely that a very long life can also be obtained from ordinary macadam stone under these conditions. They make an admirable and washable street surface for use in poor neighborhoods, where cleanliness and impermeability are of first importance.

SMALL-STONE SURFACE.—In another experimental piece he has adopted a cube of a size, roughly, 2¼ × 2¼ × 2¼ ins., and finds that he can get such a material broken sufficiently accurately for paving by hand at a cost not much exceeding ordinary macadam.

It will be noticed that as this depth, together with about 1 in. of stone bedding, is only about one-half the depth of the 6-in. sett used on the dock road, the same weight of material will cover a surface about twice as great, while as its cost per ton is about one-third there is an ample margin to provide for the extra cost of labor in paving the smaller pieces.

This surface has been paved on a depth of small broken stone of the same material, and the joints have been racked with small hard shingle, and both the joints and the layer of broken stone on which the surface stones have been embedded have been grouted and rendered impervious with the pitch mixture used in Liverpool.

The whole surface has been laid on a 6-in. concrete foundation, so that there may be no settlement; and as experience has already shown that there is no possibility of side movement, even with sharp or triangular stones embedded in the pitch mixture, it would appear that the

condition of the full-sized sett paving have been arrived at as nearly as possible in the cheaper coating.

Assuming, as well may be the case, that such a paving should have a life of 30 years under the average conditions of traffic on county roads, it would appear that a cheap and durable surface coating may in this way be obtained.

The example piece on these lines has only lately been put down, and it is as yet too soon to express any opinion on its merits from actual experience.

Road Maintenance.

By F. G. CARPENTER.*

TRACTION ENGINES.—Only a few years ago the majority of vehicles using the roads were horse-drawn, whereas now a large percentage are self-propelled, comprising traction engines, heavy motor-cars (each permitted to draw heavily-laden trailers), and the ordinary motor car. Traction engines are used purely for hauling purposes, the damage done being caused by the great weight of the engine itself, by excessive vibration, and by the rigid and ribbed construction of the tires. Many of the main roads in the West Riding are subject to constant traction-engine traffic, with the result that in wet weather they are badly damaged, while on the break up of a frost the injury done to the surface is very considerable. Traffic of this description is due to the ordinary requirements of business, and the cost of making good the damage done cannot be recovered; that for injury due to the transport of extraordinary loads, such as castings, amounting to 50 or 60 tons in weight, is recoverable, though in no case can the amount recovered be considered adequate, as in addition to the visible damage there must always be some the effect of which is not immediately apparent.

MACADAM.—The effect of the altered conditions of traffic has been to emphasize the defects of the ordinary class of macadamized roadways, and to create a demand for a roadway, which, in addition to being of sufficient strength, shall be impervious to moisture, and, therefore, practically mudless and dustless. The present and much condemned method of binding together the aggregate of an ordinary macadam road by the use of road scrapings is productive of the greater part of the mud and dust found so objectionable, but for rural roads the cost of providing a better glass binder is prohibitive. Tar has so far proved to be the best material for binding, and its use has led to the production of many patented forms of tar-macadam. To substitute tar-macadam on all our roads would entail enormous expenditure, and it can, therefore, only be expected that the various highway authorities will undertake the treatment of those lengths of main roads that pass through towns or villages.

The size of the metal generally used on the main roads in the West Riding is 2½ ins., that for patching purposes being 1 in. or 1½ ins. It is my opinion, however, that the time has arrived when the metal for roads subject to constant locomotive traffic should be increased in size from 2¼ to 2½ or 3 ins., for though this increased size may tend to the formation of a rougher surface, it would increase the resistance to crushing, and would also strengthen those roads where the foundation is faulty. The 2¼-in. metal makes an excellent roadway, but difficulty is experienced in obtaining it well and cubically broken, with the result that by the time the surface is consolidated a considerable proportion is badly crushed, rendering the road liable to more rapid destruction by traffic.

The outcry against the use of road scrapings as a binder would, without doubt, be reduced if it were not that roadmen find it easier to produce a finished appearance with the aid of a liberal supply of scrapings than without, which practise, whenever detected, is quickly stopped. Chippings are used as a binder in some districts, but their general use would add considerably to the cost of maintenance.

Owing to the disintegration of the surface an ordinary macadam road requires constant attention, and it is incumbent upon all road authorities to include in their road equipment the scarifier, horse brush, and horse scraper. A considerable saving in manual labor is effected by the use of these machines, and the work of maintenance is consequently carried out with greater dispatch and at less cost. In addition, the judicious use of the two last-named machines will greatly reduce the discomfort caused by mud and dust.

A surface made with a bituminous binder undoubtedly makes the best macadam roadway, and although the initial cost may be heavy, yet the ultimate cost will in all probability be found to be as cheap, if not cheaper, than the ordinary water-bind. By the use of a bituminous binder it is ensured that the road will form less dust and mud, and will also be practically impervious to wet, and, therefore, less liable to disintegration.

Experimental lengths of tarred granite, tarred limestone, and tarmac have been laid down on some of the heavily-trafficked roads in the Riding, and so far the latter material is giving the best results, but whether its ultimate life will warrant an extension of its use cannot yet be determined. The initial cost of tarmac is high, but has certainly much in its favor. The first cost of the materials on the experimental lengths laid complete was as follows:

Tarmac.....4s. 5d. per sq. yd.
Tarred granite.....2s. 2d. to 4s. 6d. per sq. yd.
Tarred limestone.....1s. 8d. to 3s. 6d. per sq. yd.

The thickness of the coating of each of the materials was 4 ins. consolidated, laid in two layers, the bottom being 3 ins. thick of 2¼-in. material, and the top layer of 1 to 1½-in. material. In comparison the cost of ordinary granite macadam in this county varies from 1s. 3d. to 1s. 9d. per sq. yd. Experimental lengths of tarvia have also been laid in the West Riding, but sufficient time has not yet elapsed to enable satisfactory conclusions as to its suitability to be arrived at. The cost of the material laid complete works out at rather less than 2s. per sq. yd.

During the past two years several lengths of main road in the urban or built-up districts have been tar-

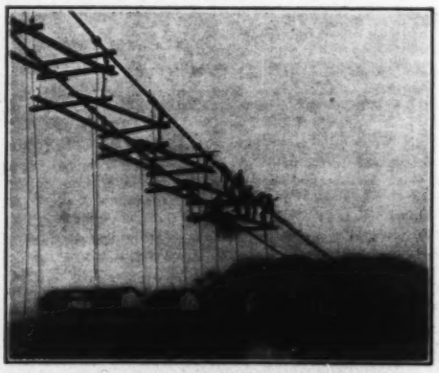

Fig. 10. Temporary Staging for Work of Hanging the Suspenders.

sprayed or tar-washed, and, with few exceptions, this treatment has given great satisfaction. Most of the work was done by machine, and cost ⅛d. per sq. yd., which, added to the cost of sweeping and sanding, brought up the total to about 1⅛d. per sq. yd. This treatment undoubtedly prolongs the life of the metal by about 20%, thereby repaying the cost of the dressing, in addition to the saving in discomfort to the inhabitants in the immediate locality.

The unsuitable nature of many of our roads to-day is not due to the absence of better forms of construction, but to the lack of money with which to carry out the required alterations, and until the money available is substantially increased little improvement can be expected. Additional revenue could easily be obtained by the increased taxation of locomotive and motor traffic, and with the assistance of a liberal grant from the Government much could be done to satisfy present requirements, especially if all main roads were absolutely vested in county authorities.

*County Surveyor, West Riding.

Construction and Maintenance of Roads, Wear and Tear, Etc.

By ALBERT D. GREATOREX,* M. Inst. C. E.

TRAFFIC.—The passage of vehicles over a road produces several effects, which it is important to distinguish. There is, first, the grinding and crushing action of the wheels and horses' feet on the surface; secondly, the effect of the load in giving rise to bending and cross-breaking strains throughout the whole thickness of the road coating. When the materials are loose and unconsolidated, either because they are freshly laid or from having been disintegrated, there is a third action—namely, a displacement of them by the wheels and horses' feet, accompanied by a rubbing together of the stones among themselves.

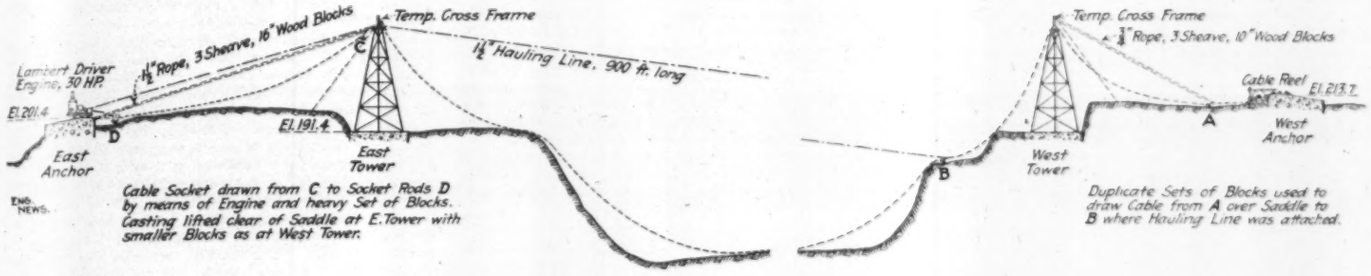
Temp. Cross Frame
1½" Rope, 3 Sheave, 16" Wood Blocks
Lambert Driver Engine, 30 HP.
1½" Hauling Line, 900 ft. long
El. 201.4
El. 191.4
East Anchor
East Tower
Cable Socket drawn from C to Socket Rods D by means of Engine and heavy Set of Blocks. Casting lifted clear of Saddle at E. Tower with smaller Blocks as at West Tower.
Temp. Cross Frame
1" Rope, 3 Sheave, 10" Wood Blocks
Cable Reel
El. 213.7
West Anchor
West Tower
Duplicate Sets of Blocks used to draw Cable from A over Saddle to B where Hauling Line was attached.

FIG. 9. SKETCH OF ARRANGEMENT FOR STRINGING CABLES.

Another damage that has now to be met is the scrubbing off of the road surface owing to fast motor traffic. This allows the wet to pass through to the very foundations, and after a frost brings about the complete disintegration of the road.

It is not now so much a question of the roads wearing into ruts—that can be dealt with by having the ruts filled up from time to time—but the whole surface of the road is one series of holes and loosened material, due to the use of the roads by heavy motor cars, which can only be remedied by coating the surface with material that will not be torn up by the scrubbing action of motor tires and the disturbing action of heavy motor-car axle weights.

Almost the whole of this damage results through the roads being constructed of water-bound granite, which in itself must of necessity be to a large extent friable. It is next to impossible when a road is being constructed with the help of water to get every stone to dovetail in with its neighbors and remain in the position into which it was originally rolled. Various road binders other than water have been used in order to secure the material in its place.

BINDERS AND DUST LAYERS.—Any material used as a binder for road making, or for dust laying, should have the following qualities:

(1) Form a perfect waterproof crust.
(2) Be as effectual in wet weather as in fine.
(3) In dry weather reduce dust to a minimum.
(4) Must not be affected by sun, nor break up after frost.
(5) Non-slipping for horses and other animals.
(6) Prevent skidding of mechanically-propelled vehicles.
(7) Afford even rolling contact with wheels of all types, and thus materially reduce tractive effort.
(8) Be equally suitable for all classes of roads and all types of traffic.
(9) Suitable for road making or repairing in wet or fine weather.
(10) Must not contain any substance deleterious to paint, rubber or clothing.
(11) Must not contain any chemical capable of poisoning fish or animals by admission to water-courses, nor be dangerous to tree life.
(12) Do without the addition of any sand or other dust-forming material to the surface.

Construction and Maintenance of Roads.

By GEO. A. PHILLIPS,† Assoc. M. Inst. C. E.

About two-thirds of the total area of the county of Glamorgan is populous and urban in character owing to the mining and kindred industries. Portions of the remaining area are less thickly populated and more

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†County Surveyor, Glamorgan.

rural in character, with agriculture as the chief, though not the only, industry.

The traffic using the county main roads is very considerable in amount, and of a heavy rather than of a light character. Compared with the main roads in English counties, those in Glamorgan are mostly narrow, in some cases being not more than 15 ft. to 16 ft. between the fences. They are, however, similar to most of the roads in Great Britain in having little or no properly constructed foundations.

At present the length of main roads under the direct control of the county council is 184 miles.

STEAM ROLLERS.—Steam rolling of the main roads was systematically commenced in this county in the year 1898-9, when a steam roller was supplied to each district. Year by year the work of maintaining the roads became greater, until in the year 1902-3 each district was supplied with an additional steam roller, all of which are employed throughout the year. Each roller has a crew of five men, inclusive of a foreman spreader who has charge of the men, and is responsible to the district inspector for the proper carrying out of the work. A weekly report is made on a printed form to the county surveyor, showing in detail the amount and nature of the work carried out by the roller gang. This report is signed by the foreman spreader and the steam-roller driver, and countersigned by the district inspector. The section men, whose lengths average 2¼ miles—the longest section being 4⅞ miles—attend to the sweeping, scraping, cleansing of ditches, etc., the smaller repairs required in the intervals of steam rolling, and assist the steam-roller gang when carrying out work of recoating their lengths.

ROAD WIDTHS.—Since the advent of mechanically-propelled traffic the county council have spent and are spending large sums of money in widening and straightening the main roads, as well as in widening and strengthening bridges and culverts, and generally improving the drainage. Where it is possible to widen the metalled surface without acquiring additional land a minimum width of 20 ft. of metalled surface has been adopted for rural areas, but this width is increased in the neighborhood of towns to 24 ft. and over. This work has been and is being paid for out of the annual rate.

In the majority of cases, however, it is necessary to obtain additional land, and a minimum width of 30 ft. between the fences has been adopted wherever this is possible, which admits of a metalled surface 24 ft. in width and one footpath 6 ft. wide. Where buildings are subsequently erected along the road on the opposite side to that on which the footpath is constructed, the local authority usually keeps the building line back to admit of an additional 6-ft. footpath being constructed.

These improvements, entailing as they do in the cases of roads running along the sides of valleys the building of heavy retaining walls, are very costly, and the work is being paid for out of loan, the periods allowed for repayment being 20, 25 and 30 years, according to the nature of the works.

DUST LAYING.—To cope with the dust nuisance, surfaces have been sprinkled with calcium chloride solution, and, although the nuisance has been somewhat minimized, the success has not been great. The author does not recommend the use of hygroscopic salts, for the reason that the keeping of the roads moist and soft tends to the more rapid wear of the surface. On each section of road that has been sprinkled in the manner indicated it has been noticed that the surface has worn into holes more rapidly than the adjoining surfaces which were not sprinkled.

Tar spraying the surfaces has been carried out with success. The first section done on a main road in this county was carried out by hand with ordinary gas tar thoroughly boiled at a cost of slightly under 1d. per sq. yd. for two-coat work, including sanding. Part of the length of road so treated was a hard stone surface and part a limestone surface. While in both cases the abatement of dust was attained, the trial was more generally successful on the granite surface, this being probably due to the better wearing quality of the stone. Subsequently another section was tar sprayed by machine, and, although this was carried out at a less cost—namely, about ⅝d. per sq. yd. for two-coat work—its effect was not quite so lasting as that done by hand. In both cases, however, the trials were successful, and there is no doubt that the preserving effect which it had on the roads treated has more than justified the expense, as the treatment added at least twelve months' life to the roadway. Tarring of footpath surfaces has also been found very effective, resulting in great saving in the cost of maintenance, while affording much cleaner and more pleasant surfaces to walk upon.

With the present experience the author is of opinion that tar spraying or painting the surface of a road well constructed with hard stone on a strong foundation promises the best and most economical results, both in the matter of dust abatement and suitability for modern traffic. Waterproofing the roads in this manner enables the camber of the road to be reduced to a minimum. Care should, however, be taken to properly construct the road with hard surface material on a sound foundation, and to tar the surface before it has been worn into holes or depressions.

The Systematic Patching of Macadamized Roads.

By J. S. PICKERING,* M. Inst. C. E.

While so much attention is at the present time being devoted to new methods of road surfacing in order to meet modern requirements, it is remarkable that little or no consideration is given to the simple but important operation of repair and maintenance by systematic patching. The practice now prevailing both in towns and in country districts is to allow the roads to get into a general state of disrepair, and then to resurface them, or, where patching is attempted, the depressions are, as a rule, filled in with loose stone, which is left to be ground to dust or to be scattered by the fast-moving traffic, a system—or, rather, want of system—which cannot be too strongly condemned. However carefully a macadamized road is made, depressions will appear in the surface long before the road actually requires recoating, and if these defects are neglected the life of the road must necessarily be shortened. If a newly-macadamized road is kept under observation during wet weather it will be seen that inequalities of the surface, which at first appear to be small and unimportant, gradually develop with the action of the traffic and the rain water, until depressions occur which allow the water to be retained and the structure of the road to be weakened. Instead of allowing these depressions to remain and to become worse year after year, they should be systematically repaired as they appear.

When the roads are dry and hard the depressions should be neatly cut out and filled in with suitable patching metal, the smaller material removed being applied with any additional material necessary for binding purposes. After periods of rainfall the surface may not require to be loosened, and in this case the depressions should be filled with metal of a suitable gage and covered with new binding material. Rolling and watering should then be proceeded with until the surface is uniform with the adjoining portion of the road. A patch applied in this manner may not require a shovelful of metal, but it necessitates the application of water and the use of a steam roller. In practice it is found inconvenient and costly to use an ordinary steam roller and a water cart for patching purposes, the result being that the work is seldom systematically carried out.

SPECIAL STEAM ROLLER.—The author has overcome these difficulties by the use of a specially-designed steam roller and water tank combined.

The length of the roller over all is 12 ft. and the width 5 ft. The rolling wheel, which is placed at the rear, and on which the bulk of the load is concentrated, is 3½ ft. wide and 3½ ft. in diameter. A water tank of 200 gals. [240 U. S. gals.] capacity is placed over the rolling wheel, the water being distributed behind through a perforated pipe 3 ft. wide. The distributor is divided at the center so that a spread of either 1½ or 3 ft. may be given. The top of the water tank is formed into an iron box in which cast-iron blocks are placed to enable the weight on the rolling wheel to be adjusted to the work it is required to do. The following are the weights of the machine under different conditions:

	Tons	cwt.	qrs.
Weight on rolling wheel without added weights and with water tank empty.....	4	7	1
Weight on rolling wheel with tank full of water but without added weights.....	5	6	1
Weight on rolling wheel with added weights and with water tank empty.....	5	18	3
Weight on rolling wheel with tank full of water and added weights.....	6	17	3
Total weight of machine without added weights and with water tank empty.....	6	19	2
Total weight of machine with added weights and tank full of water.....	9	10	0

This roller has now been in daily use for the past nine months, and is found in every way satisfactory. It does its work quicker and better than an ordinary steam roller, and its cost has already been more than saved in economy over the old system of carrying out repairs. The staff engaged in patching consists of the roller driver and two men. The metal used for patching is drawn by the roller in a dobbin cart, which holds about 2 tons. The roller travels at the rate of 6 mi. an hr., and when rolling the speed is reduced to about 2 mi. per hr. The water tank is filled from the fire hydrants, or when working outside the water-main area the supply is taken from the nearest watercourse, a steam water-lifter, with suction hose, being provided for this purpose.

The process of patching is a very simple operation, and as the same men are employed for the work they become so expert that it would be impossible a day or two after the patching is carried out to detect the position of the depressions in the road which had been made good. In order to show the sensitive and easy reversing action of the engine, it may be mentioned that the roller can be made to pass over a patch 18 ins. long no less than 30 times in a minute. It is surprising to find what a small quantity of water is required when it is properly applied. The two taps governing the supply to the spreader at the rear are under the control of the attendant and not of the roller driver, so that the supply to the area being rolled can be regulated without waste.

When not required for road repairs the engine may be used as a tractor or for street-watering purposes, a tipping body to carry 4 tons and a water tank to hold 1,000 gals. being made interchangeable. Springs are fitted on the main axle for use when hauling or street watering. A suitable chocking arrangement is provided to make the springs inoperative when rolling. This, however, has not been found necessary in practice, and the springs have a decided advantage in rendering the machine much less noisy in use than an ordinary roller.

The machine is most suitable for rolling tarmacadam roads, and it has been found specially serviceable in backing up street crossings and in maintaining a proper level the narrow strip of carriageway which is always a source of trouble where it adjoins a tramway margin. It has also been used with success in finishing off a newly resurfaced road after the heavier rollers have partially consolidated the material, the advantage being that a true and compact surface is obtained without crushing the road metal. The roller could be made still more useful if it had attached to it a single-tined scarifier. The author believes that if suitable patching rollers were employed by county authorities there would be a considerable improvement in the condition of the roads throughout the country, and the cost of maintenance would be appreciably reduced. The number of rollers usually provided by county authorities does not permit of the patching work being carried out systematically, and even if the rollers could be spared for this purpose from their usual work of resurfacing, they would be found too cumbersome and unwieldy to properly perform the work, and the use of horse-drawn water carts would be found too costly and impracticable. There can be no doubt about the economy of mending roads under the system advocated, to say nothing of the convenience to vehicular traffic. The author believes that the proverbial "stitch in time" is as true in its application to the repair of roads as in any other connection, but, simple and elementary as the process of patching macadamized roads may appear, the fact that, although its importance is generally recognized, it is seldom carried out in a systematic and scientific manner is a sufficient reason for bringing the matter before the conference.

It should, perhaps, be mentioned that the roller described is not protected in any way by patents.

*Borough Engineer, Cheltenham.

Wear and Tear of Motor Traffic on Roads.

By W. J. TAYLOR,* M. Inst. C. E.

In dealing with this question of wear and tear of motor traffic, the writer offers no apology for considering its effects on poor roads repaired with local material, as this is the condition of affairs in a very large proportion of the mileage of even our main roads, and if there were no weak roads the deliberations of this conference would possibly not be necessary.

The writer's experience of the effects of high-speed traffic on long mileages of rural main roads has been that it hastens the deterioration of the surfaces in some respects more rapidly than can be accounted for by a mere increase in the number of journeys made.

On well-made basalt surfaces where large-gage stone is used, the effect of unarmored pneumatic tires (except where the traffic is concentrated in one track) has probably not been so destructive as ordinary iron tires, the area of contact in the former case being greater, but on roads repaired with flint and gravel the reverse has been the case, the finer particles have been drawn from the interstices of the stones, thus unkeying them, and the loosened material is crushed by all kinds of traffic, and there has been much loss.

It is, however, against the armored tires that our most serious charge is levelled, and complaint is widespread of the damage caused by studded and other forms of armored tire on all kinds of roads.

Injury is inflicted by the studded tire in several different ways; in the turning movement the loosening effect of the studs is very noticeable; again, by reason of the small area of the iron studs through which the load is transmitted to the road surface, defects in contact appear to be intensified, and the rolling effort has a greater disturbing effect on the macadam. On account of the leaping or galloping motion acquired by cars running at a high speed, contact with the road surface is more or less intermittent, and the vehicle proceeds with a series of impacts, when the steel studs are not only destructive by reason of the shocks with which the small area of metal points is brought down on the road surface, but they corrugate it by kicking out the material. When the wheels, which are the medium of propulsion, leave the ground, they revolve at a greatly increased velocity, and when they again come down it is the road surface which has to do the work of reducing this revolving file to the speed of the car, with the result that portions are worn out of the road in its resistance to this tangential force; and many lengths of our roads repaired with all kinds of metal bear witness of this by the long lines of depressions and corrugations in their surfaces.

Another potent cause of damage to road surfaces is the wheel of small diameter which the makers of cars, especially those of the heavy type, have adopted. The well-known experiments of Morin early in the last century

*County Surveyor, Hampshire.

and of those other investigators who have followed him, have, unfortunately, for some reason, not been followed. It is so well known how the rolling resistance is reduced as the diameter of the wheel is increased, and that passing over unevennesses in the surface is accompanied by less shock with large than with small wheels, with consequent saving both to road and vehicle; that it is specially unfortunate that car designers have not been able to help the road problem in this direction, more especially when it is borne in mind that the limit of usefulness in merely broadening tires is soon reached, as on a portion of its width only can a cylindrical tire bear on a cambered surface, whereas by increasing the diameter the tread may safely be reduced in width. Roads under the writer's control have suffered very serious damage by the action of the small wheel. It sinks into the surface and imparts a wave motion to it by the forward or pushing effort, and the crust is disturbed, water admitted into the road, and the material loosened and lost by rubbing, attrition, and displacement.

These influences of the motor, making for the destruction of the road, are, however, greatly intensified and the cost of coping with them augmented when the traffic persists in holding to the center of the road. It is the tendency of all vehicles to keep to the center of the road, where the traffic is not sufficient to compel them to continually break track, and no doubt defects in the road have in places largely contributed to this center tracking, but even where the sides are strengthened and the cross-fall reduced to a maximum of 1 in 24 it is most difficult to induce traffic to distribute the load, and so evenly and uniformly wear down and reduce the whole surface from margin to margin, thus enabling the engineer to avoid those costly and unsatisfactory patchings and repairs in detail. The combined effects of small and armored wheels continually traveling in one track is to depress, groove, and often to cut through and destroy the surface of the road, no matter what material it may be made of; and it is a curious fact that it should be left to automobilism (to which good roads are so essential) to put upon the road surface the most destructive and, from the point of view of economical rolling contact, the most unscientific wheel that has ever been devised.

Effect of the Horseshoe and Narrow-Wheel Tire on Roads.

By the RIGHT HON. SIR J. H. A. MACDONALD, K.C.B.

To test the question what it is that, given a good road, causes it to begin to show signs of breaking up, including loss of level, development of mud and dust, and penetration by water, which is the true cause of final failure, it is necessary to consider the matter in the light of ascertained facts.

The best test to be found of the effect of horse traffic is the case of a narrow road, such as a road along the side of farm fields, where the vehicles follow one another in the same track. We find in such a case that in the center of the road there is a space about 18 ins. wide, in which all the true elements of a road disappear if the track has been left unrepaired. In this space there is in dry weather a soft velvety carpet of mixed dirt and horse droppings. On either side of this there is first a ridge of unused road, and then outside these ridges two deep ruts, the surface at the bottom of each rut being, if the ground is not absolutely level, quite close and polished, unless where a boulder or brick is lying in it. At any low-lying part of this wheel track, the water which has run down from the hard surface lies and creates a constantly deepening hole. Now, this illustration of the farm road supplies the elements by which we may judge of the effect of horse traffic on a surface which is not firmly held together. The reason why the center of the farm road is loose and velvety is because the toe action of the horse in hauling has gradually dug its way down until the loose cushion formed on the surface is sufficient to protect the ground below. The rut of the wheels is caused by the wheel gradually cutting its way down until the weight has so compressed the ground below that it is compact and immovable.

On a road where there is room and varied traffic, of course, no single line is made, but the effects as regards the foot disintegration and the wheel disintegration are the same, only combined. Every horse in pulling a load uses his toe as a gripping power to prevent slipping when he sets his weight forward to move the load, and this is, of course, done with more force when ascending a gradient. Now, as the stones in a road bound with mud cannot be tightly held, the horse's toe slightly moves a stone in its seat, a wheel going over that stone moves it again, and the wearing of the sharp surfaces has begun. Whenever by repeated movements the stone has got slightly rounded, the next picking action of the toe of the shoe tends to pull it out. Then comes the action of the wheel. The dimple left by the horse's toe is crushed down on both sides by the wheels, and if the stone is loose in its hole and the edge of the wheel comes on the side of it, the wheel turns it over and presses it out, or if the stone is out of the hole the crushing down widens the space left empty. Then comes the rain, and a small puddle is formed. Another toe deepens the hole, another wheel widens it, and so a large puddle is formed, from which water works its destructive way down to the bottoming, exposing the whole to the bursting effects of frost. While this process is going on the motor-car comes along, the pneumatic tire sinks into the hole, and with a sucking action pulls out the loose mud or loose detritus, and so adds very seriously to the damage.

This is a true history of road destruction where the road is made in the ordinary manner, and the lesson it teaches is that it is bad economy to make a road of stones and wet dirt, however much you may roll it down. It contains the seeds of its own destruction from the first.

Dust: Chief Causes and How to Avoid Them.

By T. H. YABBICOM,* M. Inst. C. E.

The [dust] palliatives employed [in 1908] were either the application of tar by one of three methods, or of a chemical in solution. The total length of macadam roads to which tar was applied was 50½ miles, while chemicals in solution were applied to 20½ miles.

TAR TREATMENT.—The application was made in one of three ways: (1) By means of a heavy traction machine traveling at the rate of about 2 mi. per hr., the tar being sprayed over the surface of the road through nozzles under pressure. As the roads so treated were about 8 or 9 yds. wide, the machine was able to cover the whole width of the road in two journeys. Forty-one and a half miles were so covered; 34½ miles of these roads having essentially suburban traffic, while 7 miles in the city district are subject to the heaviest vehicular traffic. Immediately before the tar was sprayed the surface of the road was carefully brushed clean and free from all droppings and fine dust. Directly the tar had been distributed a thin coating of fine, sharp Bideford sand was scattered over the whole, enabling the newly-treated surface to be used almost immediately. This sand is a fine, clean, sharp grit, which does not absorb the tar and thus deprive the road surface of its waterproof coating. The whole expense of the first cleaning, the tar spraying, and the sanding averaged .95d. [under 2 cts.] per sq. yd.

(2) By means of a portable hand-spraying machine; this was tried only on roads of light traffic. The machine is of a very simple character, easily worked by two men, but has the disadvantage of having to be taken to the depot frequently for refilling or accompanied on the road by an ordinary tar boiler, the latter plan being found the most practical. This little machine sprayed over a mile and a third of the roads of light traffic very successfully, but the force of the tar through the delivery holes is scarcely sufficient to cause as much penetration of the surface of the macadam as is necessary where there is considerable wear and tear. The cost worked out at .58d. per sq. yd.

(3) Tar painting by hand labor was again resorted to on 7¾ miles of road of average traffic. Far more tar is used in this process, the results are not so even, and the time occupied to cover a piece of road considerable. The cost averaged 1.41d. per sq. yd.

The costs named above mean the total cost for the whole season of the tar treatment by whichever process was adopted.

TREATMENT BY CHEMICALS IN SOLUTION.—The object is to maintain a damp surface by the use of a deliquescent salt. About 20½ miles were so treated. The beneficial results disappeared after intervals of four to six weeks, according to the state of the weather, and had to be renewed. A certain amount of watering was also necessary to keep the surface moist. The costs varied therefore from ⅜d. to ¾d. per sq. yd. for the season. Chemicals were chiefly valuable on steep gradients, where it would not have been safe to have used tar.

COMPARISONS AND COSTS.—The dust nuisance was reduced to a minimum during the whole season by one application of tar; at the same time it was not possible to do away with the watercart altogether on the treated roads, for dust accumulates on the surface and in the channels from a variety of sources other than the disintegration of the macadam by traffic, and has to be dealt with. One advantage of such a surface as is produced by the thin layer of tar is to enable the dust that does accumulate to be easily removed, or its tendency to blow about minimized by a very slight sprinkling of water in the early morning.

One season differs so much from another that it is almost impossible to make a comparison in figures of the amount of watering saved by the treatment. One fact, however, is significant. In the residential district of Clifton, which is essentially one of macadam roads, and where nearly one-half of the total mileage of treatment was carried out, the average number of watercarts in use daily during the summer of 1906, before any treatment was tried, was twenty-five, and the quantity of water distributed 13,349,000 [Imp.] gals, 1906 having been a moderately dry summer. The summer of 1907 was wet, or showery, and therefore not useful for the purposes of comparison, but the summer of 1908 was again dry. The effect of the treatment was that only a daily average of fifteen watercarts were required on all classes of roads in the Clifton district, including the untreated as well as the treated roads, and the consumption of water fell to 7,926,000 gals. Thus in this one district alone the cost of the water and the distribution was reduced by £862.

The cleansing of the roads treated with tar was effected in a much more satisfactory and thorough manner than was possible in other cases. It is not, however, in dry weather only that the advantage of the treatment has been felt, for during wet weather no mud worked up, the roadways being almost as passable for pedestrians as the footways. Of course, no saving could be expected on cleansing where chemicals were employed, the very means by which the dust is prevented being the continued dampness of the surface.

The actual saving in repairs to the roads due to the use of tar is very difficult to be represented in money in any particular year, as there are such a variety of circumstances influencing the question. The repairs in 1908, to roads that were in first-class condition before tarring, have been practically confined to small patchings with tarred macadam. In one district no repairs have been necessary to any tar-sprayed road during the season except where trenches have been opened. From a very careful consideration of the present condition of the roads, and of the opinions of the district surveyors in charge of the roads, the author is of opinion that the treatment with tar will effect an ultimate saving of from 20 to 25% of the cost of repairs.

It has been abundantly proved that tar, wherever it has been put and in whichever manner it has been employed, has effectually attained the object of dust prevention; also that the chemical treatment produced the desired end, though in a less degree.

That the treatment has not been unduly expensive is shown by the total cost of all the processes having amounted to £3,468 on 71 miles of road [about $235 per mile—Ed.]. When the roads were watered by contract the schedule price for the distribution of water on this length would have been £4,118, not including the cost of the water. The cleansing has been done in a more thorough and systematic manner on the roads treated with tar than is possible on the others. The necessary repairs have been much less frequent, and may reasonably be expected to show a valuable reduction on an extended term of years. The lasting effects have varied much according to the amount of traffic on the roads. Where that has been heavy and continuous very little or no remains of the treatment was to be seen by Christmas. On suburban roads the good effects are still evident in the more rapid drying of the surfaces of the treated roads than of those not tarred, the result being less mud to be removed, and consequently less deterioration. In many roads where the traffic has worn away the tar from the center the sides still maintain their good surface.

It has been only by a fairly extended trial that an average of results has been obtained. Circumstances vary much, and so do the effects. The direction of the road on the points of the compass, and whether it is open to sun and air or shaded, are material factors.

*City Engineer of Bristol.

TRADE PROSPERITY has ruled in 1909 and is likely to rule in 1910, according to the statistics collected by the National Association of Manufacturers. Inquiries sent out to each member of the National Association of Manufacturers have been compiled by the journal of the association, "American Industries," and show an overwhelming majority in agreement as to the excellent record in 1909 and the bright prospects for business during the coming year. The reason underlying this prosperity is not far to seek, in view of the report of the Secretary of Agriculture, showing that the value of agricultural products in 1909 broke all records, reaching the stupendous sum of nine billion dollars. With such conditions in the foundation industries of the country, there can be little question that funds will be available for the construction enterprises on which engineering largely depends, in the coming year 1910.

RAPID ROCK TUNNELING was done on the Rondout Siphon of New York City's new Catskill Aqueduct during November. This siphon is about 4½ mi. long, and is worked from eight shafts. The south heading from Shaft 7 made a heading advance of 461 ft. during November (29 working days), which is near the highest figure attained in American work with percussion drills. The bench during the same period was advanced 516 ft. The tunnel was taken out to a circular section about 16 ft. in diameter, the upper half being driven as heading and the lower half taken out in bench. It is in Hudson River shale. Ingersoll-Rand air percussion drills were used, 4 machines in heading work and 2 in bench work. The explosive is 60% gelatine forcite, 1½-in. The work during this record month was prosecuted in two 8-hr. drilling shifts and three wrecking shifts. All muck must be taken out through the shaft, 514 ft. deep, which was 1,400 ft. away at the beginning of the month. Two narrow-gage tracks are laid in the tunnel, close up to the bench, on which the muck is hauled. This work is on the contract of the T. A. Gillespie Co. Mr. Robert Swan, Vice-President, is personally in charge for the firm, and Mr. R. J. Gillespie is Tunnel Superintendent. Mr. J. Waldo Smith is Chief Engineer of the Board of Water Supply and Mr. L. White, Division Engineer on the section where this work was done.

Cooling Towers for Steam and Gas Power Plants.*

By J. R. BIBBINS,† Jun. Am. Soc. M. E.

The subject of this paper is one which has received relatively little attention in the past. The cooling tower has been looked upon as a makeshift, and its use has been correspondingly restricted. This, however, is largely due to the extremely limited available information of an exact or technical nature relative to the possible performance under unfavorable weather conditions, as well as to the somewhat uncertain factor of depreciation. And, further, it is the author's belief that the present high prices‡ constitute the greatest obstacle to the more widespread adoption of the cooling tower in both turbine and gas power plants.

Believing that interest may be aroused in this subject by a more widespread dissemination of engineering data, the author will present for discussion a type of tower with which some personal experience has been acquired, and suggest a type of combined fan and natural draft which would be suited to most efficient running on peak as well as light loads. It is not the intention to discredit the cooling tower in its present forms but rather to bring about a more general recognition of its inherent advantages.

Present Field.

There is a continual demand for cooling towers from inland power stations where the condensing water supply is costly or restricted. Turbine-driven plants, as a rule, operate with higher vacuum than those engine-driven, with the result that the performance demanded of the tower must be proportionately better. In the past, cooling towers have generally been associated with badly run plants and low vacuum. This however, is clearly a question of design and adaptation and not an inherent fault. To be sure, service requirements are not easily met (see Fig. 1). Not infrequently atmospheric temperatures of 90° to 100° F. are encountered, with cooling water at 80° to 90° F. and relative humidity above 85%. Yet the auxiliary plant must be moderate in bulk and the power consumption low. Furthermore, it must be capable of overload capacity to tide over daily peak loads and periods of excessively hot and humid weather, and all of this with small investment cost.

Curiously enough, there is an active demand for cooling towers in the South, e. g., Florida, where the atmospheric conditions are the most unsuitable; also in the western mining and coast regions. Fortunately, low humidity prevails here as a general rule (e. g., at Colorado Springs) it ranges around 50%).

In gas power work, the demand for cooli... especially pressing. The large quantity o... quired for engine jackets and for gas cooli... ing, entails a heavy expense if water is scarce... Gas-engine discharge water, being quite pure... be wasted, but cooled and returned to the p...

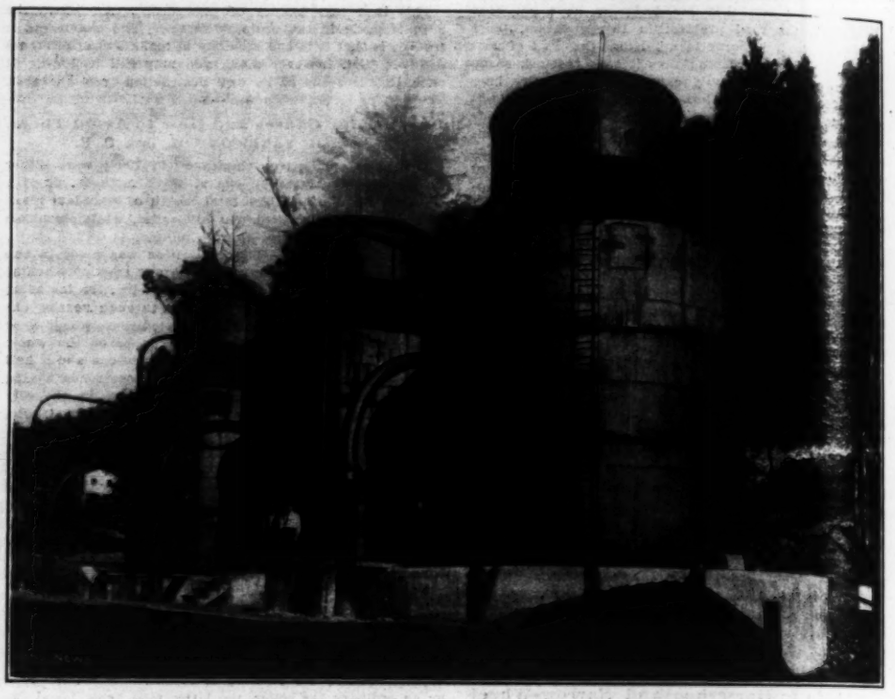


FIG. 2. AUXILIARY-FORCED-DRAFT COOLING TOWERS AT GARY, W. VA.

(These towers serve a 3,000-KW. turbine installation. Auxiliary fans in the stacks are driven by direct connected Pelton wheels supplied with water by small turbine-driven rotary pumps in the power station. Towers operate on natural draft when not heavily loaded.)

with deep well pumps supplying sufficient water for cooling, a station is handicapped by a large expense for auxiliary power consumption. In one instance of an Arizona mining plant, the only water available for cooling was so impure as to make it necessary to install a completely closed cooling system for the engine jackets, in which no evaporation took place, simply cooling by conduction. In city light and power plants, not located on water frontage, cooling towers built upon the roof have been utilized for engine cooling. The expense for buying city water for this purpose would otherwise be prohibitive except in large plants.

REPRESENTATIVE INSTALLATIONS.—As examples of present cooling-tower practice in connection with high-grade power properties, the following may be mentioned:

(a) At Gary, W. Va., (Fig. 2), three towers 25 ft. in diameter by 18 ft. high serve a plant of both high and low-pressure turbines recently installed in connection with a non-condensing engine plant furnishing the mines with light and power. A unique feature is the induced-draft fan located in the stack and driven by a Pelton water motor, which is served in turn by a small turbine-driven centrifugal pump in the power house. This equipment will be referred to later in connection with the combined natural-forced-draft type.

(b) The 13th and Mt. Vernon station of the Philadelphia Rapid Transit Co. is another low-pressure turbine plant employing forced-draft cooling towers.

(c) At the central station at San Luis Po..., in the

*Abstract from a paper presented at the annual meeting of the American Society of Mechanical Engineers, Dec. 9, 1909, New York City.

†Engineer, Public Service Commission, New York City.

‡Some recent quotations from a number of builders of forced-draft towers suitable for a load of several thousand kilowatts (not including the motor or engine for driving the fan) ranged between $4.80 and $6.93 per KW.; as much as the entire condensing equipment.

TABLE I.—WEATHER CONDITIONS, PITTSBURG, PA.

Date.	Average temperature, degrees Fahr.	Average humidity, per cent.
1904	52.8	73
1905	52.1	68
1906	52.0	70
Average	52.3	70.5

MAXIMUM TEMPERATURE AND HUMIDITY RANGES, SUMMER OF 1906.

Temperature.	Days in month— June.	July.	August.	Average for month.
Above 90°	..	..	2	0.6
" 85°	6	9	14	10.5
" 80°	8	14	10	20.5
" 75°	10	6	4	27.7
" 70°	5	2	1	23.7

Humidity.	Days in month— June.	July.	August.	Average for month.
Above 90%	3	1	3	2.3
" 80%	14	10	15	13.0
" 70%	8	11	11	10.0
" 60%	3	8	2	4.3
" 50%	2	1	..	1.0

Data from Pittsburg Weather Bureau.

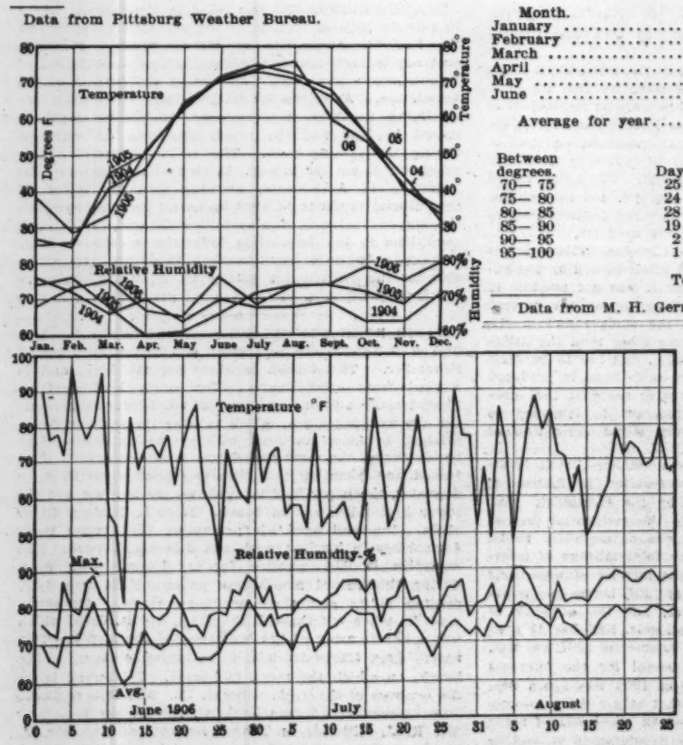


FIG. 1. CURVES SHOWING AVERAGE DAILY AND MONTHLY TEMPERATURES AND RELATIVE HUMIDITIES AT PITTSBURG, PA.

TABLE II.—WEATHER CONDITIONS, BUTTE, MONT.

Average Temperature and Humidity, 1894—1904 (Weather Bureau, Helena, Mont.).

Month.	Temperature, degrees.	Humidity, per cent.	Month.	Temperature, degrees.	Humidity, per cent.
January	23.7	66.8	July	62.8	45.3
February	23.9	68.6	August	62.9	43.4
March	28.3	60.8	September	52.0	53.6
April	40.0	54.3	October	45.1	54.4
May	49.0	54.9	November	33.7	62.7
June	52.0	50.0	December	26.5	70.5
Average for year	41.6			58.9	

TEMPERATURE RANGES

Between degrees.	Days.	Above degrees.	Days.	Per cent, year.	Hours.	Per cent, year.
70— 75	25	70	99	27	276	3.15
75— 80	24	75	74	20	196	2.22
80— 85	28	80	50	13.7	158	1.8
85— 90	19	85	22	0.6	51	.58
90— 95	2	90	3	0.82	9	.097
95—100	1	95	1	0.28	1	.01
Total			249	67	681	7.9

Data from M. H. Gerry, Jr.

FIG. 3. OPEN-TYPE, STEEL COOLING TOWERS AT SAN LUIS POTOSI, MEX., SERVING 1,500 HP. GAS-POWER PLANT.

(One tower serves the engine jackets and the other the producer scrubbers. Towers are encased by wire screen to reduce water loss from wind. Cooling, 10°—30°. Relative humidity generally about 50%.)

Mexican highlands (Fig. 3), separate cooling towers serve engine and producer systems, the make-up water being furnished from deep well pumps. This plant has been in operation since 1904.

(d) Western plants of inexpensive construction are the Mt. Whitney Power Co. (Fig. 5), and the Colorado Springs Light & Power Co. (Fig. 4), both turbine plants.

(e) Perhaps the best example of the adaptability of cooling towers is an equipment designed and built by the Helena Power Transmission Co. for its auxiliary turbine station at Butte, Mont. (Fig. 6).

This last tower was made the subject of an exhaustive preliminary study and subsequent test by the company's engineering organization, and through the courtesy of Mr. M. H. Gerry, Jr., Chief Engineer and General Manager, the writer has been able to place the complete report at the disposal of the society for future consideration. The tower (shown in Fig. 6) serves a turbine plant of 4,000-KW. capacity at 28-in. vacuum. The designers state that after two years' experience the results coincide closely with the theoretical deductions made before its construction.

Operation and Design.

Two important factors fortunately contribute to the effective operation of a cooling tower:

(a) One factor is the well-known characteristic of a natural-draft tower considered as a "chimney"—increase in capacity with increase in temperature head.

In steam work, especially with high vacuum, the general range of condenser-discharge temperatures is relatively low; in gas work, on the other hand, it is high. Pistons are to-day operated at temperatures of 140° to 160°, cylinders from 120° to 150°, occasionally higher. Owing to the small volume of water in the minor circuits, such as valves, packings, etc., these temperatures have little effect upon the average outlet temperature of the engine, which ranges from 115° to 130° in the large engines, up to 140° in the smaller sizes and verticals. This would correspond to a very poor vacuum in a steam plant, not more than 24 ins. to 26 ins.; practically out of the question in turbine work. However, this high temperature results in a high rate of heat dissipation in the tower per unit of cooling surface, with a corresponding reduction in bulk of tower.

(b) The second factor relates to developments in the efficiency of the steam-condensing plant.

The function of a condenser is, primarily, that of a water heater and the measure of its efficiency as a condensing vessel is the difference between the temperature of the exhaust steam and that of the discharge water. A theoretically perfect condenser would heat the outgoing cooling water exactly to the temperature of the incoming steam. But in practice, from 10° to 50° difference exists, depending upon the type of condenser and the volumetric ratio of water to steam. A good surface condensing plant with dry-air pump should operate at 28-in. vacuum with a temperature difference of 15°; often it is more, and the author has seen 25° to 40° difference in some of the largest stations in the country. A good barometric or centrifugal jet condenser, with dry-air pump, should operate with a temperature-difference of 10° to 15°. Although it is possible for this type to operate on less—perhaps 5° to 10°—commercial practice rarely concedes such results.

A very recent development in air pumps has made it possible to operate on still smaller difference, from 2° to 5°, with a reasonable water ratio, and even to approximate theoretical conditions. All this is in the right direction. The smaller this temperature differential, the higher the maximum inlet temperatures—both of water to condenser and air to tower—permissible for a given set of conditions. The curves in Fig. 7 show this relation in approximate form—vacuums possible with varying condenser and fixed cooling tower performance. For example, with 28-in. vacuum, 20° differential in the condenser, water ratio 60, and 15° cooling in the tower, the highest possible temperature of outside air would be 65° F. With warmer air, the vacuum would necessarily fall. Under the same conditions, with 10° differential, a maximum air temperature of 76° would be permissible; and with 5°., 81° inlet air. It is therefore apparent that the tendency of modern condenser development toward higher efficiencies will materially assist in the successful operation of cooling towers under extremely adverse conditions.

The most important elements entering into the design may be considered under the following heads; having special reference to the enclosed type of cooling tower, which for a given floor space has by far the greatest cooling capacity:

(a) Type of cooling surface.
(b) Water distribution system.
(c) Draft and air distribution.

Following are a number of essential points that seem to the writer to have a most important bearing upon any type of tower designed for maximum duty and efficiency.

All tortuous or unduly obstructed passages should be avoided. It is of no advantage to give ample spacing in one part of the tower and contract it in another, unless sufficient stack height is provided to overcome the additional resistance.

Avoid free falling water. It should be distributed so as to descend clinging to some form of wetted surface.

Avoid open spaces in the mat work, usually occurring at points where it is difficult to fill in between the frame of the tower. This will "short-circuit" and invariably diminish the effectiveness of the working sections.

Reduce working section to minimum possible height, adding extra stack if necessary. The power required to elevate the water is important, and the working height of the tower is lost, even in a closed-condenser circulating system.

Baffles or variable spacing are often necessary to obtain uniform air distribution.

A settling basin of liberal depth is always advisable in order that entrained air may separate. In all jet-condenser installations, this is extremely important owing to the amount of air returned to the condenser; and even in surface installations, this air will find its way back to the condenser via the feed water and impair the vacuum.

All wooden mat surface is subject to swelling. Means should be taken to insure permanent alinement; otherwise serious reduction in draft area and capacity may be encountered.

For maximum effectiveness, a cooling surface is required which provides uninterrupted descent of water, in a thin film at all times in intimate contact with ascending air. If any interruption is necessary, the descending sheet should be guided into place to avoid free fall.

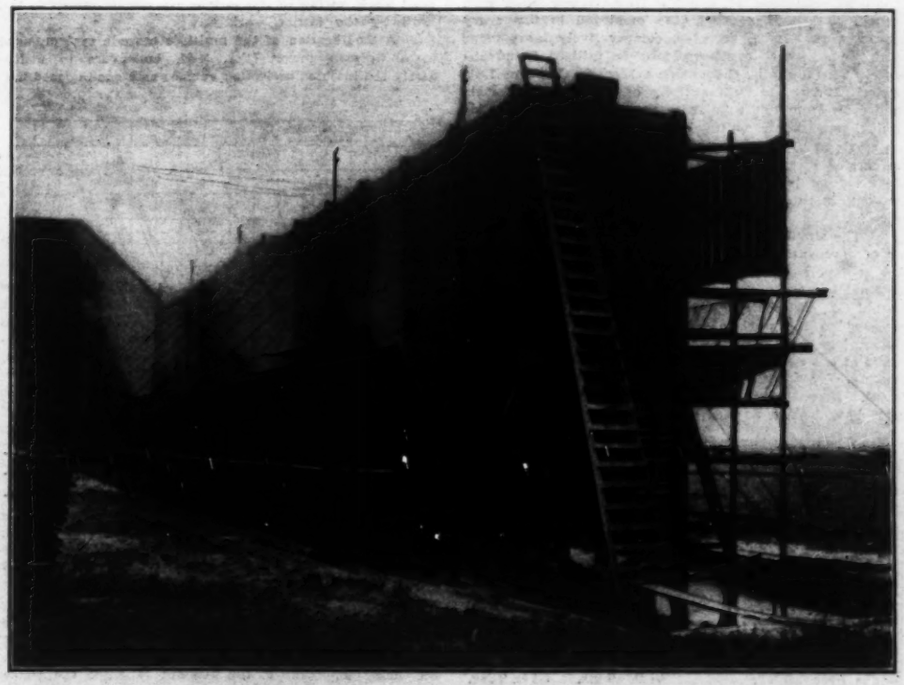


FIG. 4. OPEN-TYPE, WOODEN COOLING TOWER AT COLORADO SPRINGS, COLO., FOR 2000-KW. LOW-PRESSURE TURBINE INSTALLATION WITH LE BLANC CONDENSER.

(Wind shields at the sides reduce the loss of vapor in high winds. Cooling, 20°—30°. Relative humidity generally about 50%.)

Classification of Present Types.

The various types of cooling systems now in use naturally group themselves into a few general classes:

(a) The simple spiral-spray nozzle discharging into an open pond.—A prominent example is the 10,000-KW. Wyoming Ave. turbine station of the Philadelphia Rapid Transit Co., where this cooling pond is employed during

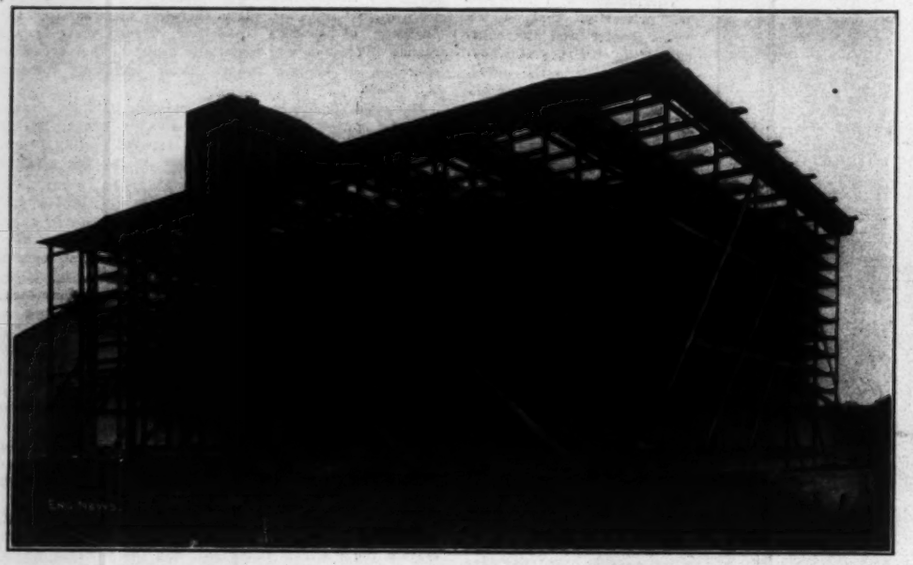


FIG. 5. OPEN-TYPE COOLING TOWER SERVING 1500-KW. TURBINE PLANT AT VISALIA, CAL.
(Data on operation of this tower are given in Table 5.)

a portion of the summer months. It has been suggested that the sprays be mounted upon the power-station roof, thereby taking advantage of the inclined surface of the roof for extra cooling effect, suitable gutters returning the water to the cold well. There might be some hesitancy about installing a reservoir on the roof; but in one notable instance, the recently designed gas-power station of the Duquesne Lighting Co., Pittsburg, Pa., the roof reservoir forms a very effective part of the cooling system. Here a small cascade type of tower assists in cooling. Without other agency this simple system requires only 10 to 20% make-up water.

(b) The simple tray type, Fig. 3, with water dripping through perforations, and cooling entirely by means of transverse air currents from the side.—Here no direct draft is possible, and the tower has no direct cooling surface. The trays operate simply to arrest the fall of the water. In this respect, the type is a simple mechanical refinement of a rough frame tower filled with brush, such as has often been employed in temporary power work. It is, however, comparatively inexpensive and, under some conditions, may be utilized to advantage. The tower of the Potosina Electric Co., San Luis Potosi, Mexico, is built entirely of structural materials and cools from 10° to 30° with very low humidities. Although encased in netting to prevent loss by spraying, as much as 10% of the volume passing through the tower is carried away during a brisk wind. The inexpensive construction is shown in Fig. 5, using horizontal wire screens instead of perforated trays and without wind screens.

(c) The simple cascade type, constructed either of wood or of corrugated sheet, in which a considerable part of the cooling is by actual conduction.—In the case of the original gas engine service plant of the Union Switch & Signal Co., Swissdale, Pa., this cascade system materially assisted in the work of cooling the gas engine jacket water, but the abstraction of heat through the concrete walls of a large reservoir was largely responsible for the cooling. This cascade system seems to have been overrated. In one prominent plant, the author understands it to have been a decided failure; in any form, it is extremely primitive and not in accordance with effective design.

(d) The multiple cascade: another representative of the simple types of construction (see Fig. 8).—Here the fall of water is simply interrupted at short intervals, and no cooling surface is installed. It is evident that successful operation is dependent entirely upon the accuracy with which the trajectory of the falling particles can be predetermined in the spacing of trays and maintained in the subsequent operation of the tower. This would require an absolutely constant head. The tower at Colorado Springs, (Fig. 4) utilizes the construction as in Fig. 8 b, a horizontal slotted surface with wind shields to prevent spray loss. This tower gives 40° cooling in fair weather. The relative humidity, however, is very low (around 50%).

(e) Several American towers are constructed simply of horizontal lattice work, usually of cypress, the numerous tiers being staggered in order to break more effectively the fall of water (see Fig 8 c).—In some, the upper and lower faces of the lattice work are beveled to lessen the resistance of descending water and ascending air. Cooling water is distributed by atomizing nozzles, by numerous spray pipes, or by a Barker's mill.* This type evidently does not lend itself readily to natural-draft work, owing to the serious resistance offered to the draft by the lattice work.

(f) A modification of the multiple cascade system, used in a German tower (Fig. 8 d), endeavors to utilize partly the inclined deflection surface as a cooling medium,

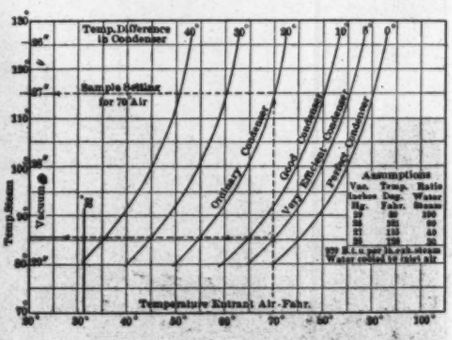


Fig. 7. Curves of Approximate Maximum Temperatures of Cooling Air Entering Towers Possible With Various Vacuums and Different Condenser Efficiencies.

although it is a question whether this is of much effect owing to the fact that the ascending air in all cases impinges on the lower surface of the deflectors, and not on the upper wetted surface.

(g) Another German design (Fig. 8 e), which has been introduced into this country, advances one step in introducing vertical cooling surface in transverse tiers. But most important is the attempt to guide the water downward in the form of a film, by forming each slat with a saw-tooth edge, meeting the lower transverse slats and guiding the water streams thereon. [illegible] signer has evidently appreciated the necessity [illegible] ing free fall of water and deliberately piped [illegible] from the flume to small troughs serving the [illegible] of slats. An American builder has modified th[illegible] (Fig. 8 f) by practically discarding the nume[illegible] of slats for vertical ones extending halfway [illegible] tower, turning them 90° at the middle of the tower, ostensibly for the purpose of equalizing air distribution. However effective this may be, we have here the desirable elements of continuously wetted surface and no free fall of water.

Fig. 6. Natural-Draft Cooling Tower for 4000-KW. Turbine Plant at Butte, Mont.

(h) A well-known American type, resembling the multiple-surface German tower (Fig. 8 e), employs numerous tiers of galvanized iron or tile cylinders, with a distributor at the top, of the Barker's mill type, propelled simply by reaction of the issuing jets.—Although highly effective in fan-type towers, there is much free falling water owing to the non-continuity of cooling surface; and in the author's experience, there is some objection to the Barker's mill distributor in the difficulty of maintaining ball bearings in proper condition. In a Detroit

*Radial arm distributor propelled by lateral reaction of its own jets.

TABLE 3.—COMPARATIVE DATA, DETROIT EDISON COOLING TOWERS.

Type.	Forced draft.	Natural draft.
Rated engine, I. HP.	1,500	900
Cooling Surface, sq. ft.	34,780	24,500
Surface per HP.	23.2	27.2
Space occupied, cu. ft.	7,064	10,850
Space occupied, sq. ft.	175	200
Cost per HP.	2.60	1.50
Cost complete.	$3,900	$1,350
Auxiliaries, E. HP.	13	....
Dimensions.		
Delivery pipe above ground.	29 ft. 0 in.	35 ft. 8 ins.
Height over all.	40 ft. 6 ins.	53 ft. 9 ins.
Height mat section.	17 ft. 0 in.	25 ft. 0 in.
Height stack.	12 ft. 6 ins.	18 ft. 1 in.
Height outlet.	10 ft. 10 ins.	9 ft. 0 in.
Diameter tower.	14 ft. 10 ins.	16 ft. 0 in.
Diameter fan.	9 ft. 3 ins.	....

TABLE 4.—DATA OF TEST OF NATURAL-DRAFT COOLING TOWER, DETROIT.
Complete, Five-Fifths Surface Installed.

		A.M.	P.M.	Average.
Engines:	Two 400-I. HP. 300-KW. MacIntosh & Seymour tandem compound engines, overhung generators.			
Condensers:	Worthington surface (admiralty type) 1,600-sq. ft.; reciprocating wet-air pump and circulating pump.			
Tower:	Wood mat construction, 24,500 sq. ft. evaporating surface, exclusive of shell.			
Date:	March 15 to 16, 1901, 4 p.m. to 4 p.m., 24 hrs.			
Weather:	Barometer (abs.), mins.	30.22	30.07; 30.14	30.14
	Temperature, air, deg.	18.5	25; 30	25
	Relative humidity, %.	76	82; 58	72
Load:	600 KW. max. to 50 KW. min. Average			244.9 KW.
	870 I. HP. max. Average			355 I. HP.
Steam:	Weight of condensed steam per hr., lbs.			5,910.6
	Temperature exhaust steam, deg. F.			134.38
	Temperature condensed steam, deg. F.			108.78
	Weight of steam per hr., max. load, lbs.			13,500
	Vacuum (abs.) 25 to 19, average about.			22
	Vacuum corresponding to temperature exhaust steam.			25
	Vacuum possible with good condenser (10° difference)			28
Water:	Circulated per hr., lbs.			293,536
	Temperature hot well, average, deg. F.			87.50
	Temperature cold well, av., deg. F.			71.27
	Vaporization loss per hr., lbs.			5,970
Results:	Condenser surface per KW., sq. ft.			2.66
	Steam per KW.-hr., lbs.			24.3
	Steam per I. HP. hr., lbs.			16.66
	Circulating water per lb. of steam, lbs.			49.6
	Steam per sq. ft. condenser surface, per hr., lbs.			3.7
	Circulating water per sq. ft. tower surface, lbs.			12.0
	Difference in temperature between exhaust steam and discharge, deg. F.			47
Cooling:	Max. 20° min. 3°-5°. Average.			16.27
	Heat dissipated per hr. B. T. U.			4,769,000
	Heat per sq. ft. tower surface, B. T. U.			195
	Heat per sq. ft. per 1,000 lbs. water. B. T. U.			0.665
Evaporation Loss in Tower:	In per cent. of circulating water.			2.03
	In per cent. of engine steam.			101
Tower:	Surface per KW. (average load 245 KW.), sq. ft.			100
	Surface per KW. (max. load 600 KW.), sq. ft.			408
	Surface per 1,000 lbs. steam max. load, sq. ft.			1.82
	Surface per 1,000 lbs. steam average load, sq. ft.			4.14
	Surface per 1,000 lbs. circulating water per deg. max. cooling, sq. ft.			5.22

station, the entire condensing plant lost its vacuum on several occasions at peak load owing to the stoppage of this distributor; and, finally, a three-deck phosphor-bronze ball bearing had to be designed to withstand the corrosion from the ascending vapor.

(f) Several builders employ continuous galvanized-iron surface from top to bottom of tower, either in the form of corrugated sheathing or of wire mesh, the water being carefully guided to the sheets so as to avoid free fall. The principle is right. With the close spacing permissible, a most intimate contact of air and descending film may be maintained.

(j) Coming now to exclusively wooden-mat construction, an example of the attempt to combine in a single slat construction all the above-mentioned desirable features, is that shown in Fig. 8 g. This resembles the form employed by Mr. Gerry, at Butte, Mont., although it is sketched from a design by Mr. Moser, of the Newhouse Mines & Smelters Co., Newhouse, Utah. The tower is of the natural-draft type with a side flume communicating with numerous transverse ducts which discharge upon continuous vertical slats, the saw-tooth construction being employed to guide the water on to the wetted surface. At the bottom, instead of allowing the water to fall freely into the receiving basin, each descending sheet is caught in a small trough and conveyed to the center of the tower, where it descends without retarding the ascending current of air. These distributing troughs reduce the effective draft area of the tower by about 40%, but the reduction in area is fairly uniform throughout the tower. This type has been found extremely effective in tests of the tower at Butte.

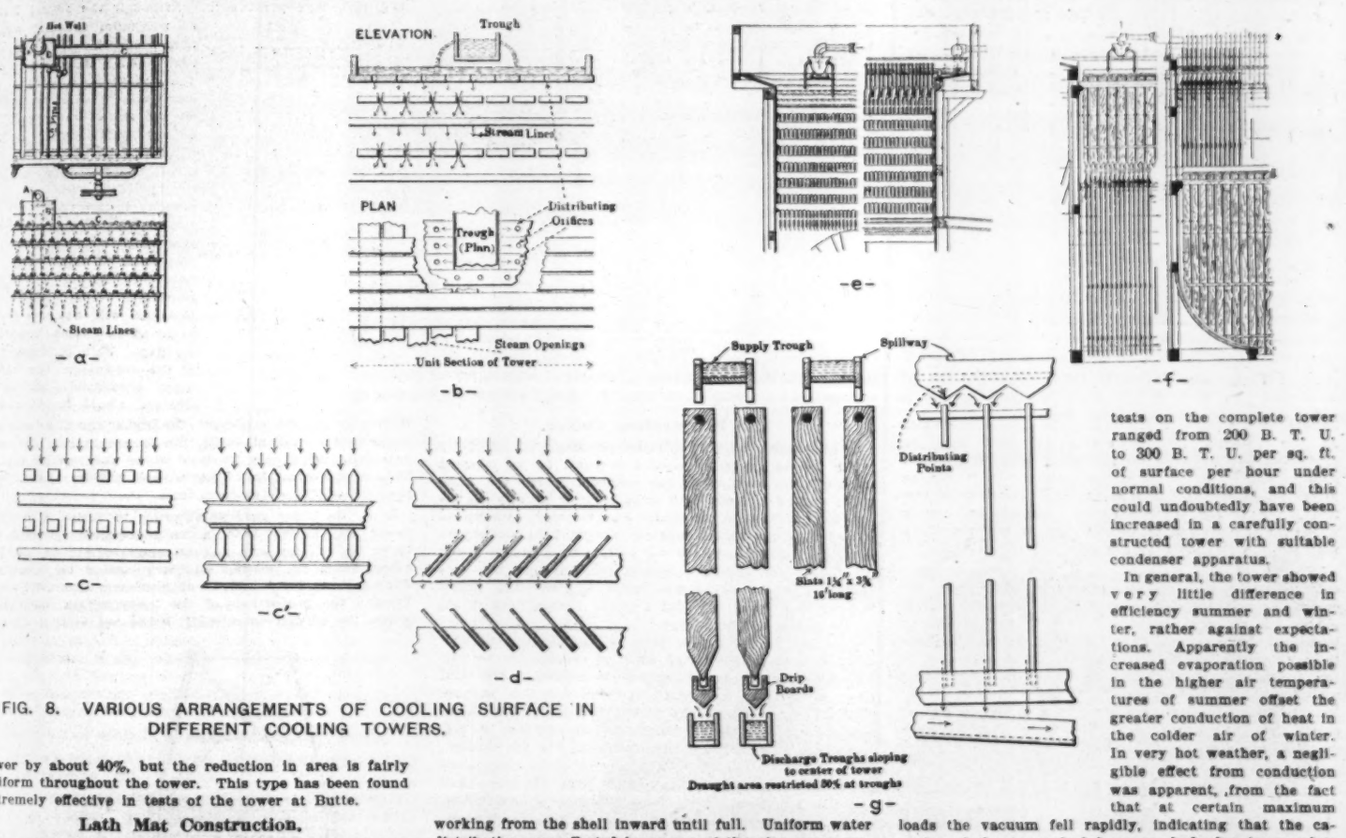


FIG. 8. VARIOUS ARRANGEMENTS OF COOLING SURFACE IN DIFFERENT COOLING TOWERS.

Lath Mat Construction.

In a design originated in Detroit, Mich., described in Engineering News, March 20, 1902, an attempt was made to subdivide the cooling surface into sections or tiers, while maintaining the advantages of continuous vertical surface. This it was thought would facilitate the construction and repair of the tower; it was also hoped to avoid the distortion of the mat surface occasioned by the swelling of the timber, which it is hard to avoid when long slats are employed. For example, this difficulty was experienced in a large gas-engine cooling tower in Texas, where plain horizontal platforms were used, with boards spaced far enough apart for the water to drip through. After some time in service, the timber had swelled to such an extent as practically to close off two-thirds of the tower, deflecting the greater portion of the water to the sides, where it descended without being cooled to any extent. This trouble, of course, is not so serious in the vertical slat tower; yet in a Boston plant employing rough boards set vertically on edge, the boards so swelled and warped that they practically closed the intervening air passages at certain points. This distortion may be noted somewhat in the Colorado Springs tower (Fig. 4).

The Detroit tower was designed under direction of Alex. Dow, M. Am. Soc. M. E., General Manager of the Detroit Edison Co., largely in order to try out the natural-draft type under conditions of central station operation. There were many features which could have been improved upon, but that the type of mat surface employed was extremely effective is shown by the results of tests made in 1902.* The important point in design was reduced cost of construction. With the exception of the sheet-steel shell furnished by a local boilermaker, the tower, serving a 1,000-HP. engine-driven plant, was built by unskilled labor employed about the station, and its total cost, including shell, concrete and brick work, material and labor, was in the neighborhood of $1,350. The shell was designed self-supporting with an independent internal frame work for supporting the weight of the mats. Wooden sheathing could have been used to good advantage, however, and the entire tower constructed by unskilled labor.

The mat surface was constructed of common wood lath, assembled on a form, with iron nails protected from corrosion by being imbedded in the wood. Mat details are shown in Fig. 9. These lath mats made a very desirable form of cooling surface. The rough surface kept the descending stream in constant agitation, and there was sufficient slope to prevent free falling water for any great distance, and also to constrain the ascending air to slice upward through the interstices, thereby bringing into use both sides as well as both edges of the lath. Thus a cooling surface of approximately 20 sq. ft. per running foot of lath mat was obtained. The various tiers were readily assembled in succession, working from the shell inward until full. Uniform water distribution was effected by means of the pipe-spray system, with laterals spaced like the mats below.

Two series of tests were made at Detroit at different times, first, with only the two upper tiers, and finally with all the mats in position. In this plant the condensing system was not well adapted to economic working. Air and circulating pumps were direct-coupled, making it impossible to control the tower water separately from the condensation. There was considerable air in the system from a long run of exhaust piping; and with no dry-air pumps, a vacuum of 24 ins. was normal practice. But the condenser was operated with a temperature differential of 47°, so that with an efficient condenser, a vacuum of 28 ins. might have been obtained with the same tower performance (16° cooling, 71° cold well).

The results of these tests are graphically compared in Fig. 10. Table 4 gives a summary of the final test. It was very noticeable that the rate of heat dissipation in B. T. U. per sq. ft. per hour was considerably higher for the uncompleted tower with only about three-fifths of the mats in operation. However, by the addition of the remaining mat surfaces the tower was enabled to work on lower water temperatures, and we should therefore expect a lower rate of heat dissipation. This would indicate that the upper tiers of towers were more effective than the lower. The heat dissipation during the tests on the complete tower ranged from 200 B. T. U. to 300 B. T. U. per sq. ft. of surface per hour under normal conditions, and this could undoubtedly have been increased in a carefully constructed tower with suitable condenser apparatus.

In general, the tower showed very little difference in efficiency summer and winter, rather against expectations. Apparently the increased evaporation possible in the higher air temperatures of summer offset the greater conduction of heat in the colder air of winter. In very hot weather, a negligible effect from conduction was apparent, from the fact that at certain maximum loads the vacuum fell rapidly, indicating that the capacity of the tower had been reached, due to complete saturation of air, while in cold weather the vacuum would hold up better at the same load. This shows that with air fully saturated and evaporation checked, the dissipation of heat by conduction in hot weather was quite insufficient to give an appreciable margin of overload.

This tower was in constant use for a period of about 4½ years, cooling all of the condensing water for the central station. Depreciation was at first thought to be a serious factor, but later, when the tower was finally dismantled, the frame work and mats were found to be in excellent condition. The only parts showing deterioration were the upper sheets of the tower shell lying above the distributor, where corrosion had taken place owing to the alternate wetting and drying of the surface during the last six months of service in 1905 (10-hour operation). The mats themselves were as sound as when put in. After a few months' service, the mat surface became coated with scale. This scale would accumulate, crack off and fall to the settling basin.

Although fairly successful, this experimental design might have been considerably improved. By straddling the supporting joists in the manner shown in detail in Fig. 9, the various tiers of mats may be brought together into a practically continuous surface from top to

TABLE 5. OPERATING DATA, OPEN-SCREEN TOWERS.

Mt. Whitney Power Co., Visalia, Cal.

Tower Designed for 1,500 KW.—2,000 KW. at 27-ins. Vacuum.	
Horizontal screen surface, sq. ft.	9,550
Circulating water handled, gals. per hr.	1,720,000
Rate of circulation, lbs. per sq. ft. per hr.	1,500
Dimensions, ft.	30 x 47 x 15 high
10 tiers galvanized iron screens	5 mesh per in.
Cost of tower including concrete form	$2,000
Observations, Oct. 23, 1906.	
Maximum load carried, 5.20 p.m., KW.	1,130
Temperature atmosphere, deg. F.	55
Depression, wet bulb thermometer, deg.	8.5
Relative humidity, 50% absolute; gr. per cu. ft.	2.35
Temperature incoming hot water, deg. F.	110
Temperature outgoing cold water, deg. F.	100
Cooling, deg. Fahr. (minimum for day)	10
Vacuum carried (ref. 30-in. barometer), in. Hg.	26.6
Difference between temperature steam and condenser discharge	....
Possible vacuum (10° difference in condenser)	....
Maximum cooling for day (730 KW.) deg F.	16

Data from Hunt, Mirk & Co., Engineers, San Francisco, Cal.

*Conducted by the author and by Messrs. Armstrong and Richardson.

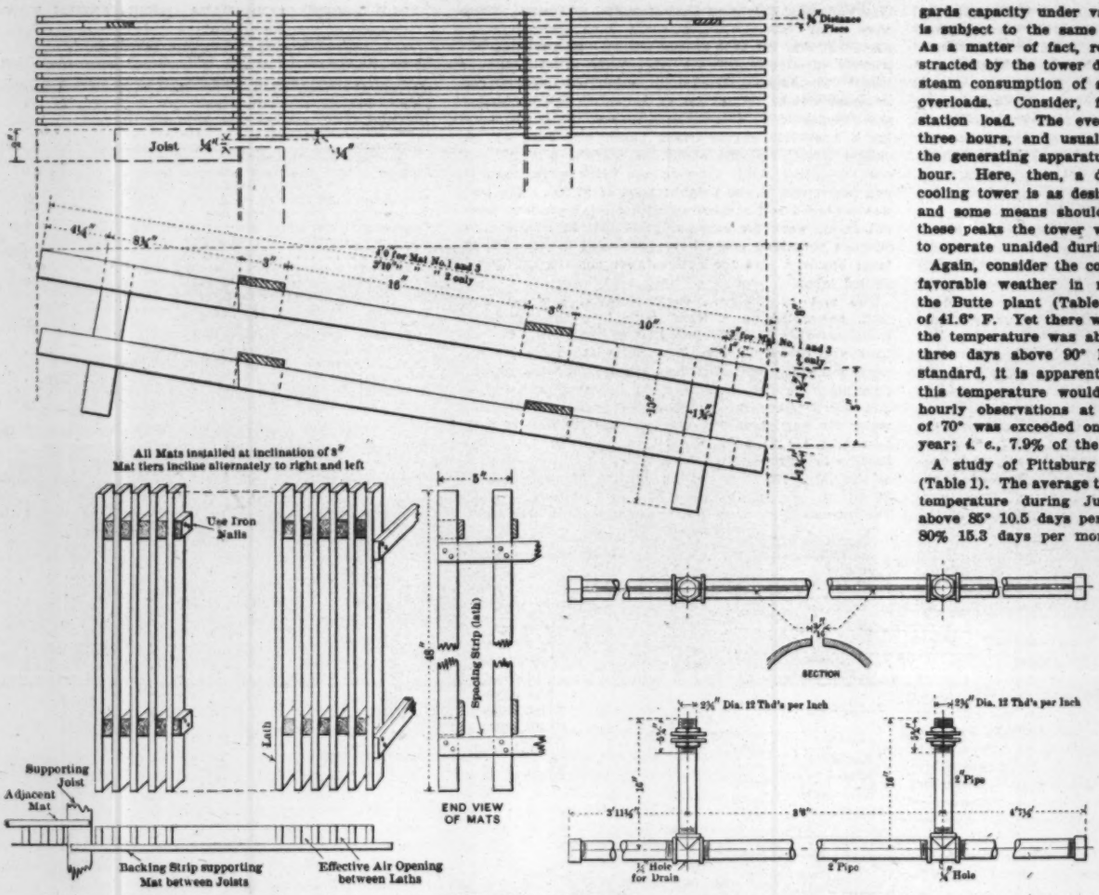


FIG. 9. DETAILS OF LATH MATS AND DISTRIBUTING PIPES FOR SECTIONAL LATH-MAT COOLING TOWER.
(With 16 laths per running foot of mat, this arrangement gives 20 sq. ft. effective cooling surface per running ft.)

bottom, thus altogether preventing the free fall of water At the bottom, the obstruction to draft may be prevented by employing deflecting troughs under each mat, to convey the water to the center of the tower, as in the Moser tower, Fig. 8 g. A better distribution system in the form of horizontal slotted laterals discharging upward and overflowing directly on to the respective mat sections is shown in Fig 9.

In any system of stationary jets, it is extremely difficult to obtain uniform distribution of water over the entire tower at different rates of flow. With the slotted pipes, it is an easy matter to open or close the slots so as to distribute uniformly, and as they are laid horizontally, this adjustment is permanent. It is also easy to free the laterals from foreign matter, as is not the case with jets. This is because of the ample section of the laterals; whereas any system using a large number of small distributing pipes or apertures involves ultimate trouble from clogging.

The Evaporative Cooler.

In gas-engine work it is often necessary to economize water to the greatest possible extent. In an Arizona mining plant employing gas engines, where the mine water was so foul and acid as to prohibit entirely its use for cooling jackets, a cooler was recently constructed of ordinary hot-water radiators arranged in series-parallel, with air forced over the surface by a motor-driven fan. The well-known counter-current system was employed, and the outfit was fairly efficient, the jacket water being cooled 15° with a power consumption of 5% of the output of the engine.

It occurs to the author that by keeping the radiator surface continually wet the effect of evaporation as well as convection might be utilized in cooling. The foul mine water may sometimes be used for this purpose without contaminating the jacket circulation. With an expenditure of 2¾% in evaporation, an increase of 24% in cooling would be obtained, assuming the air entering and leaving to be fully saturated. This system has been attempted in connection with steam condensers, but apparently without much success. The principle seems entirely logical, but the difficulty of maintaining tight joints with thin-walled tubes of sufficient diameter to permit of the passage of the proper amount of air, would seriously detract from the effectiveness of this plan in condensers by reason of air leakage. The low vacuum shown during tests of such condensers largely confirms this supposition. For gas-power plants, however, the type seems admirably suited.

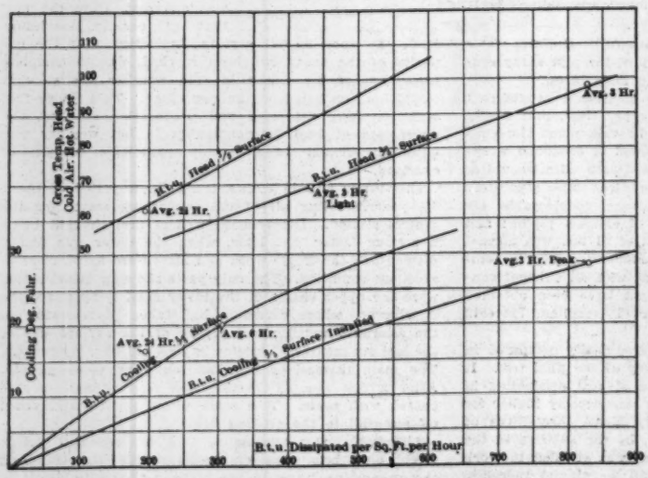

Cooling Deg. Fahr.
Avg. 8 Hr.
B.t.u. Head ⅓ Surface
Avg. 12 Hr.
B.t.u. Head ⅓ Surface
Avg. 3 Hr. Light
Avg.3 Hr. Peak
Avg. 24 Hr. ⅓ Surface Cooling
Avg. 6 Hr.
B.t.u. Cooling ⅓ Surface Insulated
B.t.u. Dissipated per Sq. Ft. per Hour

FIG. 10. CURVES SHOWING HEAT DISSIPATION OBTAINED IN TESTS OF NATURAL-DRAFT COOLING TOWER AT DETROIT.

Regulation for Load Variations and Weather Conditions.

The cooling tower should be designed with the same flexibility as other good power-plant apparatus, as regards capacity under various conditions of o[peration]; it is subject to the same peak-loads as the pr[ime mover]. As a matter of fact, relatively more heat m[ay] be abstracted by the tower during peaks owing to [the] higher steam consumption of a steam engine per H[orse]power on overloads. Consider, for example, a norm[al] central-station load. The evening peak seldom ex[ceeds] three hours, and usually the most severe d[emands] on the generating apparatus occur within a per[iod] of one hour. Here, then, a definite overload capa[city] in the cooling tower is as desirable as in the engine [or] boiler; and some means should be employed to reli[eve] during these peaks the tower which would have ampl[e] capacity to operate unaided during the remainder of th[e] day.

Again, consider the comparatively short perio[d] of unfavorable weather in normal climates. Repo[rts] from the Butte plant (Table 2) reveal a mean tem[perature] of 41.6° F. Yet there were 99 days of the year [in] which the temperature was above 70°, 50 days above 80° and three days above 90° F. Taking 70° as an empirical standard, it is apparent that for two-thirds of the year this temperature would not be exceeded. But careful hourly observations at Butte show that a temperature of 70° was exceeded only for 681 hours throughout the year; i. e., 7.9% of the actual time.

A study of Pittsburg conditions shows similar results (Table 1). The average throughout the year was 52.3°. The temperature during June, July and August averaged above 85° 10.5 days per month, and the humidity above 80% 15.3 days per month. Although the actual hours of maximum are not available from the Weather Bureau reports, it is safe to say that these unfavorable atmospheric conditions existed not more than one-tenth of the daily period, or 2.5 hours.

It is therefore apparent that the problem of maximum capacity in cooling towers involves a condition of peak load existing only 5% of the time, and of high temperature only 8% of the time. Moreover, these maximum demands will not generally occur at the same hours of the day. With 5° difference in the condenser, the maximum permissible air temperature would be 81°; the more efficient the condenser, the higher the allowable air temperature. Yet at Butte, the temperature of 85° was exceeded during only 22 days of the year, or 51 hours. This is equivalent to 2.5 hours each mid-day and to less than 0.6 of 1% of the total time.

Is it, therefore good engineering to design a cooling tower installation with a vacuum-producing capacity large enough for any and all emergencies; or, on the other hand, to provide auxiliary means for assisting during these brief periods of maximum demand, while keeping the proportions of the tower within reasonable limits for normal operation? Might not even a consid-

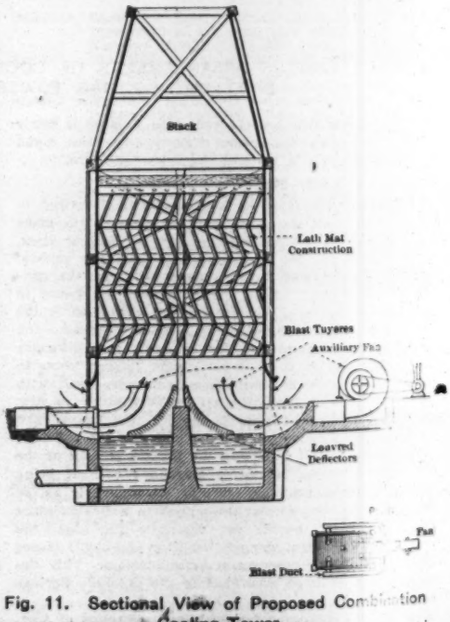


Fig. 11. Sectional View of Proposed Combination Cooling Tower.
(With auxiliary forced draft for peak loads and adverse weather conditions.)

erable impairment of vacuum under the most unfavorable operation be better tolerated than the increased expense of equipment suited to maximum demand?

This, of course, applies particularly to natural-draft towers. Flexibility already exists in the forced-draft tower through the speeding of the fans; but even here there are some drawbacks owing to the high velocities already employed for normal working. Any large increase in the velocity of the fan may seriously disturb the uniformity of air distribution over the tower surface and give rise to eddies destructive to efficiency. That this condition exists, is very plainly shown by a survey of the discharge velocity by means of an anemometer. Examination of one defective installation by this method revealed the fact that fully one-third of the area was practically ineffective and that reverse currents actually took place in some parts. The air-distribution problem is exceedingly important, and more so in the forced-draft than in the natural-draft tower, where low velocities favor uniformity.

FIG. 1. VIEW OF THE FOREST HILLS ELEVATED BEFORE CONCRETE CASING WAS APPLIED.

NATURAL-DRAFT TOWER WITH AUXILIARY FORCED DRAFT.—The natural-draft tower is of itself ill-adapted for operating with a fixed temperature head. It thrives on the weakness of the condensing system. The lower the vacuum, the better the tower works, because of the increase in temperature head. And as this is clearly a problem of chimney design, the only way out of the difficulty is apparently by some method of auxiliary draft. An increase of 25% in heat dissipation with the same temperature conditions can be effected by the use of a comparatively small fan auxiliary.

There are two methods of accomplishing this result:

1. By locating in the stack an induced-draft fan which normally remains idle.

2. By installing at the base of the tower a forced-draft system so designed as to supplement the natural draft without causing a back-flow.

An example of the first method is used in the cooling towers at Gary, W. Va. (Fig. 2). Although designed for constant service, the arrangement of the stack fan is precisely as suggested. Whether the Pelton type of motor, direct-connected to the fan, is superior to belt or chain drive from a motor mounted on the outside of the tower, is a question of mechanical convenience.

The second suggested arrangement is crudely shown in Fig. 11. The auxiliary air is delivered to the tower through four nozzles supplied from a concrete duct surrounding the base of the tower. With this arrangement, the natural draft under the base of the tower might tend to be reversed owing to the back-pressure resulting from the blast. It is believed, however, that with a fairly open mat structure such as has been described above, the introduction of four auxiliary blast ducts would serve only to entrain more air and further assist the tower in the absorption of heat.

Of the two methods, the former has the advantage of having been already put into practice. However, there is to be said in favor of the latter that no working parts, such as fan bearings, belt transmission, etc., are in the current of vapor; and with a tower operated intermittently, corrosion is an important matter, as was proved by the deterioration of the upper-sheets at Detroit. Furthermore this system lends itself more readily to a square or rectangular-shaped tower, which may be desirable in large sizes.

Summary.

1. Improved types of cooling towers are in active demand for high-grade power plants, both steam and gas, and especially for low-pressure turbine installations.

2. Effectiveness of working is largely dependent on efficiency of condenser, *i. e.*, minimum temperature difference between steam and discharge water is desirable to increase the temperature head on the tower.

3. Cooling towers are particularly adaptable to gas power plants. The bulk of the tower is reduced by the high temperature head available with hot jacket water.

4. Elements of most effective design: avoid free falling water; try to obtain maximum retardation of descent with minimum obstruction of draft; insure uniform distribution of water and air; provide the maximum exposed wetted surface for a given bulk and an interrupted descent of fluid film.

5. In locations of low humidity simple forms of construction usually serve the purpose, except where ground space is valuable.

6. Sectional lath-mat type of tower is well adapted to natural draft work. This construction is simple, durable and inexpensive.

7. Normal rate of heat dissipation obtained by lath-mat construction is 200 B. T. U. per sq. ft.

8. Auxiliary fan "booster" suggested as the best means of obtaining the desired overload capacity,—a combination of natural and forced draft. Overload conditions (high temperature, humidity or power load) usually last but a small percentage of the time—1 to 5%. Natural draft suffices for the major portion.

The Concrete-Covered Steel Structure of the Forest Hills Extension of the Boston Elevated Ry.

Just before entering the terminal at Forest Hills, a suburb of Boston, the new extension of the Boston Elevated Ry. has to cross a parked space known as the Arborway. On account of the surroundings there, particularly, the masonry arch crossing of the New York, New Haven & Hartford R. R., the Park Commissioners of the city insisted that the elevated railway structure be given an appearance somewhat more pleasing than the standard steel construction used on other parts of the road. To satisfy these official requirements the company built the structure illustrated in this article.

The portion of the viaduct that crosses the park and which is of this special construction, connects a regulation steel elevated structure to the terminal station, a distance of about 374 ft. made up of alternate 45 and 64 ft. spans. In appearance, these spans are now a series of low rise concrete arches between single pedestals in the middle of the street, carrying the two track railway on double cantilevers, from the pier and from the fascia girder (Fig. 2). This, however, is the outside structure. The skeleton, shown in Fig. 1, is four longitudinal steel plate girders supported on steel piers, made of a double line of interbraced columns. These girders rest at each end on a transverse girder, which carries the two middle longitudinal girders immediately above the two columns of the pier bent, and the two outside girders on the extended cantilever arm of the transverse girder. The extreme outside cantilever is framed onto the outside girder.

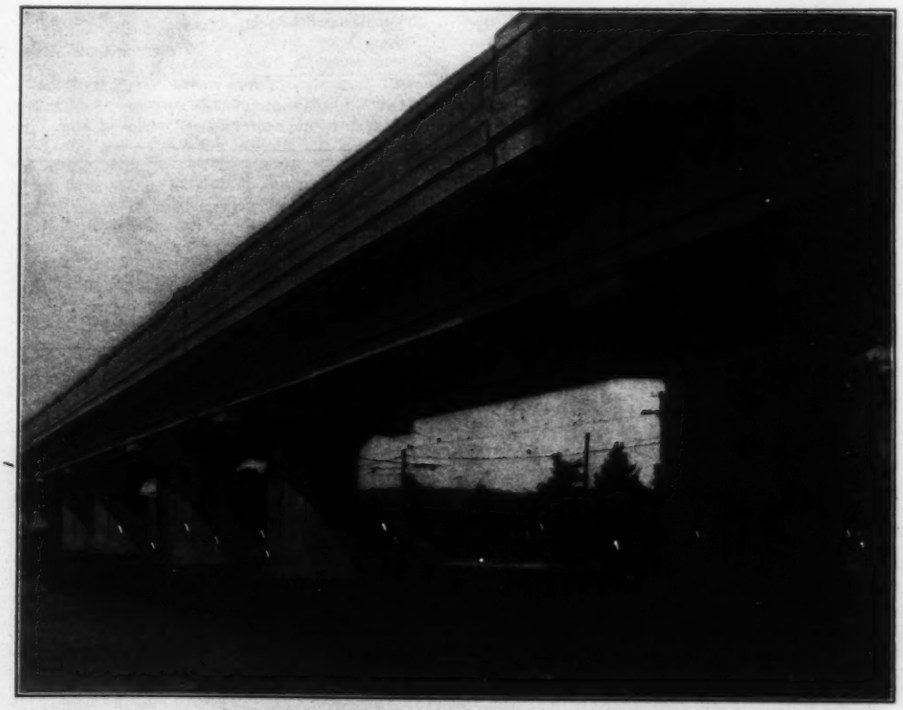


FIG. 2. VIEW OF THE FOREST HILLS EXTENSION OF THE BOSTON ELEVATED RY. ACROSS THE ARBORWAY.

This framework was encased in concrete in the manner shown in the accompanying figures. This consisted of a complete encasement of each of the four longitudinal girders and of the transverse girders, but not of the sway-bracing (see

Fig. 4), the complete surrounding of the steel pedestal, the forming of a curved surface under the bracket from the pier and under the sidewalk cantilevers, the construction of a reinforced-concrete flat-slab on the top of the four longitudinal girders to be used as a floor and the casting of a solid concrete railing.

The construction of the pedestal is shown in Fig. 3. It is a very heavy, thoroughly braced column, made up of four corner columns tied together with X-braced panels and founded on box girders resting on a concrete footing. It is surrounded with an octagonal concrete pedestal, tapering from bottom to top, and with a central 2 × 3 ft. opening, which is connected at top with the drains from the bridge and at bottom to the sewer system of the city. The concrete outside of the steel work in the pedestal is of sufficient thickness so that no extra reinforcement is needed to make it keep in place.

The concrete casing of the roadway structure follows closely the lines of the steel work and is therefore of so small a thickness that reinforcement had to be provided. This consists of a mesh of wire cloth attached to all of the steel members (Fig. 4) by small rods passing through holes punched in the steel work. On this furring a 3-in. thickness of concrete was cast in the general manner shown in Fig. 5. As the street and park below could not be obstructed by forms or centers, all of the formwork was suspended from the steel structure which was of sufficient strength and stiffness to withstand this extra strain. All concrete was a 1:2:4 mixture with stone all below a ½-in. size.

The concrete surfaces of the pedestals were washed and scrubbed after an early form removal, but the upper works could not be so treated on account of the difficulty in taking down the forms, so that all surfaces above the posts were treated with a pneumatic tool. The general effect of the surface and the design is very pleasing and in proper conformity to the surroundings.

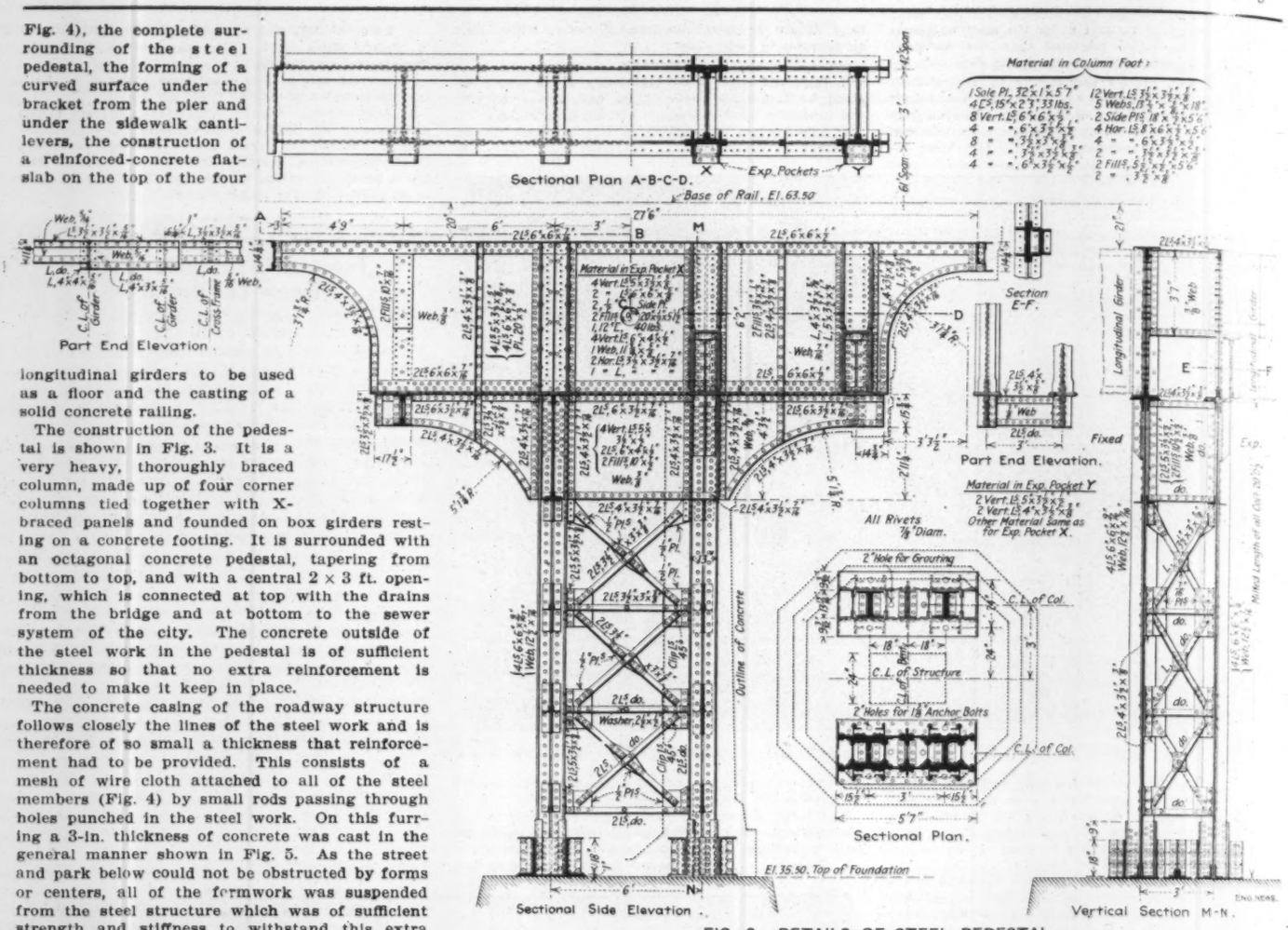


FIG. 3. DETAILS OF STEEL PEDESTAL.

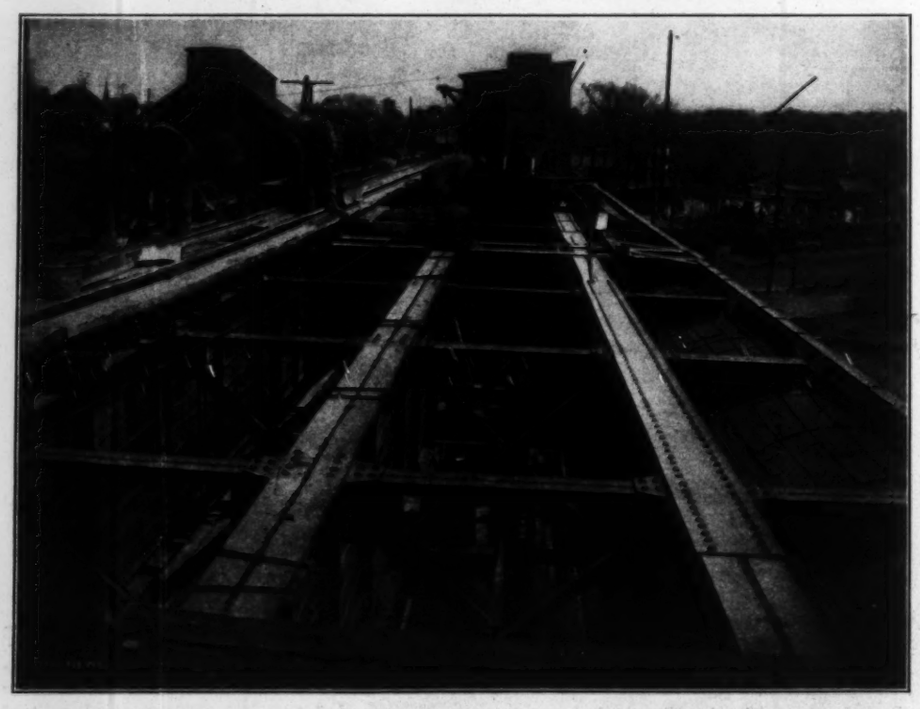


FIG. 4. CONCRETING IN PROGRESS ON THE ELEVATED STRUCTURE, FOREST HILLS EXTENSION, BOSTON ELEVATED RY.

The whole viaduct was designed as a steel structure with the exception of the slab floor, which was designed as a reinforced-concrete member. The encasing concrete, however, was not assumed to take any load, but can be counted on to give an additional stiffness to the entire structure as well as to protect it against corrosion.

The entire work was executed under the direction of Mr. George A. Kimball, Chief Engineer of the Elevated and Subway construction of the Boston Elevated Ry. Co., and under the direct supervision of Mr. C. T. Fernald, First Assistant Engineer in Charge of Construction. The architectural design is due to Mr. Edmund M. Wheelwright and the structural to Mr. Robert B. Davis. The American Bridge Co. furnished the steel work and the concrete contract was held by the Hugh Nawn Contracting Co.

TWO LARGE WAR SHIPS.—The keel plates of two monster war ships, the "Orion," the improved Dreadnought battleship, and the "Lion," the cruiser battleship, were recently laid, the former at Portsmouth and the latter at Davenport, Eng. The bulk of the material for both vessels is ready, and all arrangements have been made for their completion within two years.

The construction of the "Lion" will mark a notable stage of evolution of the cruising battleship. She will have 70,000 HP., while her immediate predecessor had 45,000. She will displace 21,000 tons, and her length will be 700 ft., constituting her the longest man of war ever laid down.

What is technically known as her "run of deck" indicates an intention to equip the cruiser battleship with ten 12-in. guns, thus placing her as regards armament on an equality with the latest battleships. She will have probably a nominal speed of 27 knots an hour.—Dispatch from London.

Annual Meeting of the American Institute of Chemical Engineers.

The second annual meeting of the recently formed American Institute of Chemical Engineers was held at the Hotel Walton, Philadelphia, on Dec. 8, 9 and 10. A varied program of business and technical sessions and excursions to industrial plants was carried out. The society now has something over 400 members and about a tenth of that number were present at the various sessions. The sessions made up, with the enthusiasm of the members, what they may have lacked in numbers.

An important amendment to the constitution was proposed, for action at the next meeting (June, 1910). This provides for a junior grade of membership. At present only those 30 years of age, holding responsible chemical engineering positions, can connect themselves with the society. Should this amendment be adopted, younger men (23 years of age and over) actively engaged in chemical engineering and having five years' experience, or holding degrees of Ch. E., E. E., M. E., or B. S. (in chemistry) will be admitted to the junior grade. It is provided also that a junior member who reaches the age of 35 must qualify as an active member or sever his connection with the society.

Specimens of the badge recently adopted (by letter ballot) were exhibited at one of the business sessions. The badge is a gold shield displaying the name of the society on a field of transparent red enamel. In shape it much resembles the familiar insignia of the American Society of Civil Engineers.

The Committee on Engineering Education presented an informal progress report stating that as chemistry courses were in a sort of transition period, active work had not been pursued. Such a program, for this committee in the future, was objected to by a few educators who expressed their need of more information on which to base changes in present curricula.

Dr. C. F. McKenna, of New York, was declared elected president after a count of letter ballots received. Mr. Eugene Haanel, of Ottawa, Ont., was declared elected a Vice-President to fill the vacancy caused by the death of Mr. H. A. Hunicke, of St. Louis. There still remains a vacancy among the Vice-Presidents through the promotion of Dr. McKenna. Prof. J. C. Olsen, of the Brooklyn Polytechnic Institute, New York City, and Mr. W. M. Booth, of Syracuse, N. Y., were both re-elected Secretary and Treasurer respectively.

It was voted that a committee should be appointed to consider the establishment of a gold medal to be bestowed from time to time on persons who should make some notable advance in chemical technology.

The presidential address of Dr. S. P. Sadler, of Philadelphia, was entitled "Conservation and the Chemical Engineer." American industrial developments were classed as explorations, exploitations and conservations. As conspicuous examples of the first, the early days of gold mining and petroleum pumping were cited. The wastes of present methods of coal mining, and natural-gas utilization marked the second stage. The third stage was indicated in the work of the chemical engineers on all sides. Greater utilization of resources and increased efficiency of industrial methods characterized the movement. As specific examples, the speaker cited the improvements in distilling illuminants from crude petroleum and the utilization of residues once wasted. Other cases were given in profusion, such as the derivation of analine and creosote compounds from gas-works tars, the development of starch products for foods, liquors, textiles and for explosives, the production of artificial nitrogen salts from the air for fertilizers, etc.

Mr. E. R. Taylor, of Penn Yan, N. Y., read a paper, "Smelting Iron Ore in an Electric Furnace," in which he described a type of stack furnace for smelting the ore to pig. This same design was described in a similar paper before the American Electrochemical Society in October. (See Engineering News, Nov. 4.) In brief, the furnace consists of a large stack having, when charged, a core of charcoal extending upward from four large carbon electrodes and surrounded by a descending blanket of flux and ore. Fine ore is fed so as to descend at the walls and is pushed in toward the center at the bottom by screws. The reduction is intended to be largely through the influence of CO_2 and but little by direct contact with the incandescent carbon. The descending blanket of fine ore serves also to absorb the radiation and conserve the heat developed.

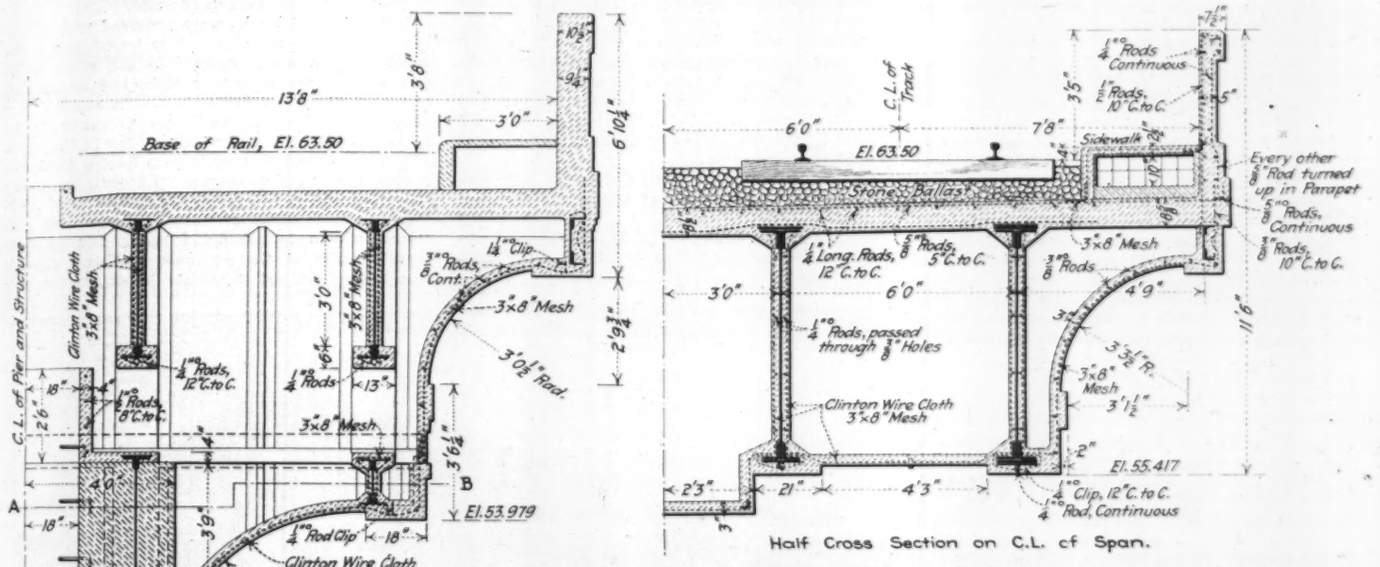


FIG. 5. DETAILS OF THE CONCRETE CASING AND SECTION THROUGH THE VIADUCT.

Mr. Taylor also presented a brief series of remarks on "Waterways and Water Powers" in which he advocated closer attention to the development of all available power in any scheme for waterways. As a conspicuous example he cited the New York State Barge Canal where no attention was being paid to utilizing the considerable power available.

At the conclusion of these remarks Mr. Taylor presented resolutions, addressed to the National Waterways Association then in session at Washington, urging full consideration of all matters relating to forestry and water storage in all waterway developments in order that all possible power might be developed to lighten the burden of maintaining the projects, and urging that all investigating bodies should associate chemical, hydraulic and electrical engineering experts with their navigation advisors. The resolutions were referred to a special committee and adopted at a later session.

Prof. C. E. Munroe, of Washington, D. C., at one of the evening sessions lectured on "The Chemical Industries of America." His address was founded on a study of the U. S. census figures for 1890, 1900 and 1905. On account of the use of a formidable array of statistics it is impossible to summarize here more than a few of the most general deductions. The growth of chemical establishments, it was held, was rather in amount of production, than in number of plants. The lot of the wage earners had improved far more than had their number. The increase in number of women employed in chemical industries was slight and the number of children had decreased. The high price of living, all over the world, was remarked on, the speaker placing the responsibility on the chemical engineers who had improved metallurgical processes so as to make possible the present "flood of gold," incidentally decreasing its purchasing powers. Higher prices were induced by all pure-food laws and by all attempts to benefit mankind. The speaker defined the great work before the chemists to be in increasing the

earning power of the individuals and in decreasing costs of production of all supplies. This work involved increasing the fertility of the soil, completing, in this country the manufacture of materials now exported raw, importing raw materials for manufactured imports, change of locations to reduce transportation costs, elimination of public nuisances and wastes, readjustment of markets to absorb industrial by-products. It was emphasized finally that all small economies were possible only by great establishments and great aggregations of capital, involving the concentration of management and the death of small concerns.

"The Commercial Extraction of Grease and Oils," by Mr. W. M. Booth, of Syracuse, N. Y., opened with a brief history of commercial fat extraction. Heat was early used and later pressure. The tendency was toward higher temperatures and heavier pressures. Of late the use of solvents had improved all such processes, cheapening the operations and increasing the percentages recovered from wastes. The solvents used were naphtha, benzole, carbon tetra sulphide, carbon disulphide, chloroform and ether. On account of the expense, the last two were not found practical. Naphtha was generally used as it was the cheapest and could be distilled from the grease without reaching a temperature at which the grease was "cracked up" into gases. All the solvents named dissolved from 30 to 35% of their weight of grease. Kerosene oil dissolved 44%, but it did not distill from the grease at a sufficiently low temperature. The wastes were treated in a closed cylinder, with heat or not, after having been dried to about 2½% moisture. Garbage (fish waste and slaughter-house offal) contains some 20% fat and 80 to 90% of this can be recovered by a solvent such as naphtha. The author maintained that the recovery of such waste greases, of a value of 2 to 25 cts. per lb., was a new national asset.

In the discussion of this paper the use of carbon bisulphides in England for the extraction of stearic compounds was shown. In Australia, another speaker said, the wool washings (containing grease to the amount of 40% of the weight of wool) were discarded in the absence of knowledge there of a desirable way of extracting the grease.

Two papers were presented on the commercial distillation of pure glycerine from the crude. These were "Multiple Effect of Distillation," by Mr. F. J. Wood, of Brooklyn, N. Y., and "Advantages of the Multiple-Effect Distillation of Glycerine," by Mr. A. C. Langmuir, of Brooklyn, N. Y. The first paper showed the history of glycerine distillation from the first direct-fired still with air cooled condensers. Next superheated steam was blown into the crude glycerine and the refined product condensed from the saturated water vapor at a temperature above the boiling point of water. Next the same arrangement was worked under vacuum, lowering the temperatures generally and thereby decreasing the amounts of glycerine lost by disintegration. In another advance, the air condensers were superseded by apparatus with which the latent heat of the vapors could be recovered. The final step shown was the combination of several stills in series, with a condenser between each pair, so that one charge of steam alternately took up glycerine in a still and discharged it in a condenser. The latent heat in all condensers was recovered. The important point in the design of the stills was in spraying the crude glycerine through the steam instead of the reverse, as common.

The second paper was in fact a continuation of the first, showing the great advantages which had been found in operating the multiple-effect process developed by Mr. Wood and described at the end of his paper.

"Reclaiming Waste India Rubber," by Dr. S. P. Sharples, of Philadelphia, was an account, more or less historical, of the development of various processes for using rubber gum and for making second-hand rubber as useful as fresh gum. The chief troublesome substance in the old rubber was the fiber of the material on which the rubber had originally been spread. If the fiber was wool it was easily removed by hot caustic alkali. Cotton fiber was more troublesome and it was often left, in well-ground refuse, as a filler. These fillers, used to give the rubber certain mechanical properties as well as to cheapen the process, were largely earthy materials, as chalk. When strong acids were used to dissolve the cotton fibers in waste rubber, the fibers could be destroyed in three or four hours without harming the rubber and by destroying less than half of the fillers. In boots and shoes 40% of the waste was filler, largely chalk. Some vulcanized-rubber waste was reclaimed by dissolving the excess free sulphur remaining after vulcanizing, whereupon the rubber could be used much as pure gum, being again vulcanizable. Such processes did not remove the combined sulphur of the vulcanizing. Dr. Sharples' paper was illustrated with samples of waste and reclaimed rubber in various stages of reclamation by several of the processes.

Two papers were presented, for the last session, by Mr. A. Bement, of Chicago. The first of these, "Chemical Composition of Illinois Coal," presented many data which have variously appeared. The second "Heat Efficiency of Smokeless Combustion and Heat Absorbing Capacity of Boilers," was in two parts. The first part contained a comparison of two boilers, one with and one without a furnace fully enclosed with a refractory lining. With the boiler setting not so fitted, a loss of 9.3% over the one properly equipped, was found on test—as the result of incomplete combustion. In the tests described, radiation losses in both were estimated by comparing the unaccounted losses and assuming that in the boiler setting with a lined combustion chamber there was no loss from incomplete combustion. In these tests the author illustrated and recommended a change of recognized methods (Am. Soc. M. E. Code), in regard to computing the air supplied for combustion. Only the available hydrogen in the coal was taken into account and the combustible was decreased by the carbon in the ash.

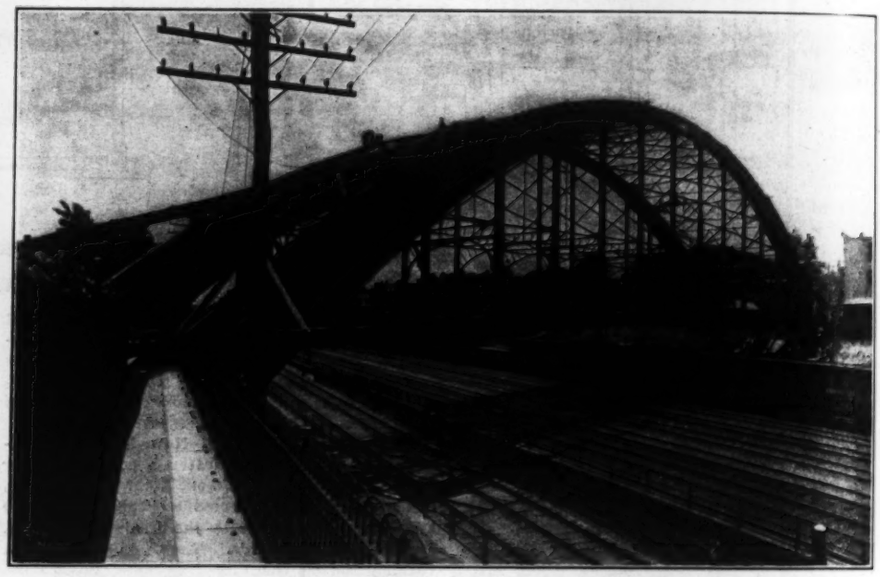
The second part of the paper was a discussion of the increased efficiency of heat absorption in a water-tube boiler by baffling the tubes so that the hot gases traveled along the tubes instead of across and at a high, rather than a low, velocity.

THE POE LOCK AT SAULT STE. MARIE was out of service only 7½ days on account of the collision with the upper gate on Nov. 10. The method by which the repairs were effected was described in our issue of Nov. 18. The traffic through the Soo canals for the season just closed is nearly equal to that of the record-breaking year of 1907, which was 58,000,000 tons, in round numbers. The total to Dec. 1 for the season of 1909 was 56,000,000 tons.

Concreting the Arch Ribs of the 42d St. Bridge, Philadelphia.

The accompanying half-tone is a view taken during the construction of the 42d St. Bridge, built by the city of Philadelphia across the tracks of the Pennsylvania R. R. This bridge was described at length in Engineering News, May 20, 1909, p. 540, has for the main arches, steel box-girder ribs spaced 15 ins. apart and filled in between with concrete. The view shows very well the type of the main framework and the manner of placing the concrete in the ribs.

The plate-girder ribs were provided with a bottom cover-plate for their whole length and a top cover-plate in which holes were left about eight feet apart, thus forming a tight box into which the concrete could be poured. In placing this concrete an 18-in. runway track was built up from the adjacent ground, as shown in the view, and the concrete run up in cars hauled by cable. Filling was carried on simultaneously on opposite sides of the rib, to ensure symmetrical loading. At each point of deposit a man was stationed was a long-handled spade and he constantly agitated the concrete and saw that it was flushed against the steel. When the box was filled up to one opening, the runway was carried to the next higher opening and the lower one closed up with a cover tap-screwed in place. The process was continued in this fashion to the crown, where the top cover plate was left open for a while to allow the interior concrete to set and then grout was pumped in to fill any voids left and the top closed with a cover.



FILLING CONCRETE IN THE STEEL BOX-GIRDER RIBS OF THE 42D ST. BRIDGE, PHILADELPHIA.

The bridge was successfully completed this fall and opened for traffic on Nov. 6, 1909.

MINERAL PRODUCTION OF INDIA.—The figures tabulated below are from an abstract of the report of Sir Thomas Holland, Director of the Geological Survey of India, printed in the "Indian and Eastern Engineer" of Calcutta, issue for November:

Mineral production.	1908 Quantities.	1908 Value	1907 Value
Coal*	12,769,635 tons.	£3,356,209	$16,100,000
Gold	567,780 ozs.	2,177,847	10,450,000
Petroleum	176,646,320 gals.	702,009	3,370,000
Salt*	1,279,937 tons.	522,794	2,510,000
Manganese-ore†	674,315 tons.	465,593	2,240,000
Saltpeter†	386,190 cwt.	292,758	1,405,000
Mica†	27,572 cwt.	139,513	670,000
Jadestone†	3,211 cwt.	73,400	352,000
Ruby, Sapphire and Spinel	.....	47,954	230,000
Graphite	2,873 tons.	14,365	69,000
Tin-ore*	1,887 cwt.	11,015	53,000
Iron-ore*	.....	10,637	51,100
Chromite*	.....	6,338	30,400
Magnesite*	7,534 tons.	2,009	10,050
Diamonds	.....	940	4,520
Amber	.....	364	1,750
Total		£7,823,745	$37,550,000

*Spot prices.
†Export values.

This is about 110% the value of mineral production for 1907.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
SAN FRANCISCO: Monadnock Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
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Road construction and maintenance in England is quite as lively and troublesome a question as it is in the United States, notwithstanding the idea commonly prevalent here that the roads of England are well-nigh ideal. If any proof of this statement were needed it might be found in the numerous papers and extended discussions brought out some months ago by the British Road Conference. Elsewhere in this issue we give a considerable amount of space to a number of the papers which seem likely to be of no little interest and suggestiveness this side of the Atlantic.

A notable feature of the Conference was the prominence given by it to the subject of tar macadam. In general, it seemed to be taken for granted that under the changes in road wear and the increase in road dust incident to the extensive use of motor vehicles the day of water-and-dust-bound macadam has passed or is rapidly passing. British conditions favor the almost exclusive use of tar, rather than asphalt or asphaltic oils, as a bituminous binder. Here, all these materials are being used in varying extent, with asphalt far in the rear as a binder for broken stone.

It is interesting to note that at the British Conference there was noted an "outcry against road scrapings as binder." In America, road scrapings are rarely if ever used as a binder, perhaps because our macadam roads are hardly ever scraped. But a binder of almost as questionable character, in view of present traffic conditions, has been widely used in some quarters; namely, clayey earth.

One of the papers read at the Conference contained a plea for systematic patching of macadam, or a return to the once-common practice of keeping macadam roads in a constant state of repair, instead of allowing them to wear down until a general resurfacing was required. Interesting ways of patching were described, as may be seen by referring to our abstract of the paper.

Another of our abstracts to which attention may be called deals with the tonnage-life of and wear of stones in road surfaces. Consideration is given to what kind of stone to use and how to use it so as to get the greatest wear at the least cost. This subject deserves more attention here, but its thorough study depends upon a thing which is all too rare in this country; that is, traffic censuses.

Finally, we would direct attention to the papers on the wear and tear of motor traffic and on the effect of horseshoes and of narrow tires on road surfaces. As to motor traffic in England, it should be remembered that very heavy freight motor vehicles and huge traction engines are so common there as to have led to parliamentary provision for the collection of proved damages to roads by them. Should American road designers take into account the possible extensive use of such engines of destruction on our roads?

After many decades of agitation for municipally-owned water-works and no end of troublesome litigation over the rates charged by the Spring Valley Water Co., San Francisco now seems to be in a fair way to join the other large cities of the country in controlling its own water-supply. The matter will be decided, it now appears, about the middle of January, 1910, by a vote on two propositions: (1) shall $45,000,000 of bonds be issued to bring in water from Lake Eleanor and the Tuolumne River (unfortunately known as the Hetch-Hetchy project) and to provide distributing works, with the understanding that if the second proposition carries the bond issue shall be cut to only $23,000,000; (2) shall $35,000,000 of bonds be issued to buy the works of the Spring Valley Water Co., which now supplies the city.

As some of our readers will remember, the city has had under consideration for many years past a plan for a supply from the Tuolumne River, far away in the Sierras. The project was brought to the attention of the whole country some months ago by the claims of certain opponents who urged that if the project were carried out the beautiful Hetch-Hetchy valley would be ruined by the creation of a proposed reservoir that would flood a large part of its area (see Eng. News, Jan. 7 and 21, Feb. 4 and 11, 1909). This valley lies in the Yosemite Reservation or national park, but should not be confused with the Yosemite Valley. When San Francisco went to Congress to ask for the exchange of certain lands which the city held for others in national ownership the scenic defenders of the Hetch-Hetchy valley brought every possible influence to bear against the exchange. They urged, among other things, that the city did not need this particular supply and that the works of the Spring Valley Water Co. were adequate or could easily be made so by extension, for years to come. Congress did not take positive action in the matter; but the city has since been proceeding with its plans for the Tuolumne works. Matters had gone so far that an election to vote bonds for the project had been called for Dec. 28, when the Spring Valley Water Co. made a series of offers to sell its works to the city. Although some were disposed to regard these offers as a mere attempt to side track the vote on the Tuolumne plan or to down the project, good sense and certain legal requirements which we need not specify have led the city authorities to cancel the election of Dec. 28 and to take steps for one at a later date at which both new supply works and the purchase of the supply and distribution works of the company will be voted on.

The two plans are not of necessity antagonistic, in view of the provision for cutting down the bonds for city construction work in case the purchase plan carries. At the same time, the people may throw their vote for one or the other plan alone, or for that matter defeat both of them.

Whatever the outcome in other respects it seems from this distance and to outsiders as though the interests of all concerned would be best served if the city voted to buy the works of the Spring Valley Water Co. For the city to build a duplicate or competing works would only be justified in case the company were very unreasonable as to price, and it seems that is not the case, since of the various offers which the company submitted to the city one proposed that the price be fixed by arbitration. We do not understand that that offer is to be considered at present, but should local sentiment regard the price of $35,000,000 too high, perhaps some means for determining the price by arbitration may yet be found.

If the city votes to buy the works it will terminate a seemingly endless conflict over rates; will satisfy the demand for municipal ownership, which will never down until San Francisco has fallen into line with other important cities of the world and gained control of its water-works; and it will clear the way for developing the additional water-supply which the city must have at an early date. Until the Spring Valley Water Co. is disposed of in a manner fair to all concerned it cannot be expected that either the city or the company will have a free hand for developing a new supply. The company will not spend much more money as long as its relations with the city are so strained and uncertain, and the city can count on opposition from the company at every possible point of endeavor for independent works. Moreover, the Tuolumne project will appear in a much clearer light just as soon as the city gains possession of the works of the company. That accomplished, the opponents of the Tuolumne supply can no longer urge that the project is simply a club to bring the company to terms. At the same time, the capacity and limitations of the supply now controlled by the Spring Valley Water Co. will be less a subject of controversy than now, and thus both the city authorities and the public will be better able to judge how imminent is the need of water from the Tuolumne River and how much water will be needed at the outset.

The design and planning of a new manufacturing plant involves a great variety of major and minor considerations, all more or less inter-related, and all of these must be coordinated and given their proportionate attention in the design in order to ensure a high degree of efficiency and economy in the operation of the plant as a whole. Elsewhere in this issue we publish some description of a new plant in which particulars are given as to some of the varied factors or elements in the design. The first consideration, as a rule, will be the general plan and arrangement of the buildings, with a view to the several processes and departments. The type of building best adapted to the work and locality must be considered, together with the machinery and tool equipment and its arrangement for the best facility and economy of work. The facilities for the delivery of raw material and the shipping of finished products form other important considerations, and auxiliary to these and the shop and machinery arrangement is the provision of facilities for handling material in and through the buildings and yards. The power plant equipment and power distribution are also among the very important considerations. Another group of factors includes the heating, ventilation, lighting, fire protection, etc. Closely allied to this group are the provisions for drinking-water supply, toilet and sanitary arrangements, etc. The importance of these two last groups in relation to the efficiency of the working staff, and therefore to that of the plant, has not always been sufficiently recognized, but is being given an increasing degree of attention.

Future enlargement of the plant must be considered in most cases. This is provided for as a rule by acquiring sufficient area to permit of horizontal extensions of the buildings. In some cases, however, vertical extensions are practicable and economical, as in some of the departments of the Corn Products Co.'s plant, described in our issue of Aug. 26, 1909. Most of these matters will be factors in the design of every plant, but in varying degrees of importance due to local conditions of climate, topography, etc.

In regard to the general layout of the plant, this must be considered usually in relation to the size, shape and topography of the site, as in the case of the plant described elsewhere. An instance where these items did not enter into consideration is afforded by the great steel works at Gary, Ind., described in our issue of Aug. 12, 1909. The planning of the general layout on the

flat sandy waste was an easy matter, but in hilly country it might have been very difficult, or even quite impracticable, to arrange any suitable plan for a plant of such extent. In this particular case, considerations of size, shape and topography were practically negligible, as the company had purchased great areas of land, almost absolutely level, and the designers had practically "all outdoors" for the arrangement of the plant. Under such conditions, however, care must be taken to guard against a tendency to spread over too much ground, and thus involve objectionable distances for the handling of material.

That this matter was given its due weight in the design of the steel works mentioned is indicated by the arrangement of the blast furnaces. The 16 furnaces (each with a rectangular casting house) are conveniently arranged in a row along the canal or slip for the ore steamers. The obvious plan would have been to place them end to end, which would have made a great length. Instead of this, the casting houses are arranged at an angle with the line of furnaces (or "in echelon"), thus enabling the furnaces to be placed more closely together and effecting a more compact arrangement without introducing any counterweighting objectionable features.

The reduced estimates for national expenditures reported in President Taft's message and which have met with general public approval were made feasible largely through an innovation in making up governmental estimates which has been introduced at Washington. That innovation is neither more nor less than the recognition and partial use of the budget principle, which is a well-established feature of government estimates abroad. A well-conceived budget includes an estimate of normal receipts as well as of proposed expenditures for a coming fiscal year, and also a plan for meeting deficits. Our practice has been to make sure of the appropriations, give scant attention to probable receipts and leave deficits to be cared for when they arise.

To meet a deficit face to face leads to a choice between increasing receipts by new forms of taxation and cutting down proposed expenditures. It also leads to placing expenditure estimates on the lowest possible level consistent with efficiency and expediency instead of making them high on the assumption that they will be cut down anyhow.

It is understood that the legislative and executive branches of the government at Washington cooperated as never before in framing the latest governmental estimates, and that the executive branch had no small hand in bringing the estimates into final shape and also into a size comportable with probable revenues. This is as it should be, and it is to be hoped that such of our state and municipal governments as have not already taken the lead will follow and improve on our national government in this particular.

The Commissioners and Auditor of the District of Columbia are trying to introduce the budget principle in the next District appropriation bill passed by Congress. It would be well, indeed, if the national government, as a whole and in caring for the District of Columbia, would set so good an example for the state and city governments to follow.

Public water-supply stoppages or shortages due to ice-clogged gate-chamber screens are not of so rare occurrence as some water-works officials wish. One of their worst features is that like most other accidents, they come unexpectedly. It seldom happens that one of these stoppages is discovered and remedied so promptly as was the case at Springfield, Mass., on Dec. 1. An interesting account of this happening and the vigorous handling which it received may be found elsewhere in this issue.

The National Bureau of Health advocated by President Taft in his first message to Congress is a proposition that should receive serious consideration throughout the country. Forty years ago we had such a branch of the government. For some reason it ceased to exist and for many reasons, most of which are not creditable, it has never been re-established. Since then hundreds of thousands of dollars from the national treasury have been used for the study of diseases of animals and plants. The money has been well spent, but at least equal sums might well have been provided for conserving the health and life of the human population. We trust there will be no longer delay in putting the United States on a par with other leading nations in this matter.

Now that the lately deceased George Crocker has given a million and a half for the study and prevention of cancer and the very-much-alive Mr. John D. Rockefeller has set aside a million dollars to combat the hookworm disease in the South, who will come forward with a like sum for use in clearing up mysterious points surrounding the continuous prevalence of typhoid fever in some of our cities since the introduction of the pure water-supplies which it was supposed would go far towards eradicating the disease?

The need for such work is particularly apparent in the South. Three years of study of typhoid conditions in Washington, D. C., by the U. S. Public Health and Marine-Hospital Service, have done little save exonerate the filtered water-supply and the domestic fly and implicate somewhat more deeply than before the public milk-supply and those most closely in contact with typhoid patients. The District Health Department has comparatively little to guide it to a direct and effective attack on the cause for half or more of the hundreds of cases reported each year. Perhaps the Pittsburg Typhoid Commission, aided by the Russell Sage Foundation, will soon throw light on this vexed subject; but even if it does, wise philanthropy could still use large sums for a study of the cause and prevention of typhoid elsewhere, and notably in the South.

At the same time, it should be pointed out that what the South needs most of all is an awakening to the value of good sanitation in city and country alike and to the fact that *with its utterly inadequate registration of vital statistics* it does not and cannot know the exact degree of prevalance of readily preventable communicable diseases and thus of course cannot be expected to conduct an intelligent campaign against them. As the recent U. S. Census Bulletin, "Mortality Statistics: 1908," says:

> Unfortunately there are as yet no Southern registration states [states in which the vital statistics are sufficiently complete and accurate to be used in statistical work].

An awakened and enlightened public opinion, rather than public benefactions, is needed to correct this glaring defect; but perhaps public benefactions used to make clear the sanitary sins of that section would so arouse the public as to lead to measures for securing complete and reliable vital statistics, which, as every sanitarian knows, are the foundation and guide of health-protective work.

Associations of Contractors and Fair Specifications.

Numerous attempts have been made to organize associations among the firms engaged in the business of general contracting. It has generally proved a difficult matter, however, to secure continued interest and activity in such associations. The reasons for this are evident enough. There are a few large contracting organizations which carry on business in a systematic way over a long period of years; but a very large part of public contract work, particularly outside of the large cities, is done by men who take up contracting, not as a regular business but as a speculative venture.

A man who has accumulated money in some other line of business hears glowing stories of the huge profits made by contractors. His gambling fever is aroused and he puts in a bid on some work about which he has accumulated that little knowledge which is proverbially dangerous. Such a man often emerges from his venture after losing a good part of the money he has invested and with the determination hereafter to stick to the line of business in which he has had experience.

Occasionally, however, such a man brings to the new enterprise sound business sagacity and a genius for organization which results in success. Even in such cases, however, it often happens that after two or three successful contracts he will relinquish the work for something involving less risk and anxiety.

For these and other reasons which we need not now take space to set forth, about the only field where a permanent and influential association of general contractors can be formed is in the large cities; and, we may add, only in cities where contract work is carried on with a reasonable degree of honesty and fairness.

A year ago there was organized in New York City an association of general contractors. This organization differed from most organizations of contractors hitherto attempted, in having a definite object and in providing means to carry that object into execution. This object, as stated in the constitution, is "to correct abuses relating to the business of its members; to secure freedom from unjust and unlawful exactions; to procure fairness, uniformity, harmony and certainty in the relations existing between contractor and contractee."

The constitution also declared that there should be no action on the part of the association "to control or in any way deal with prices or restrict competition." Annual dues were fixed at $200 for members engaged in the contracting business, and at $150 for associate members, engaged in the supply of materials to contractors. A membership of about fifty contracting and supply companies was secured, and this gave the association sufficient funds to employ a permanent secretary and legal counsel to advise the members in matters involving points of law. The association is exerting its influence toward standardization of the specifications governing contracting work in the various boroughs of New York City, and toward the revision of present specifications and contract forms so that they shall be fair and equitable as between the contractor and the city.

The association celebrated the completion of its first year in the early part of this month, with a dinner at the Hotel Knickerbocker, at which the membership was fully represented and the work of the association for the year was reviewed by its officers.

There is good reason to believe that a proper association of contractors, organized on such lines as this, may be of much usefulness in promoting the cause of honest and economical municipal government, even though its primary object is to protect the business interests of its members. For many years Engineering News has argued in favor of fairness and equity in the framing of specifications and contracts. The matter is one which has come to be well understood by engineers, but it is, unfortunately, little understood by the general public.

An engineer fully understands that when a contract is so drafted as to throw upon the contractor a large burden of risk and uncertainty, the public must in the long run pay a high price for the work it has to have done. On the other hand, if a specification and contract is so framed as to reduce risk to the lowest possible limit, a contractor doing an honest and straightforward business can afford to bid very closely on the work and reduce his percentage of profit down to what would be expected in mercantile business. Unfortunately, this matter, which is exceedingly simple when once understood, is not comprehended either by the general public or by municipal officials and lawyers who have the final say in the drawing of city contracts. An engineer cannot argue that a contract should be so framed as to place the burden of risk on the city and not on the contractor, without the criticism being raised at once that he is not protecting the interests of the city which employs him.

It might be thought that contractors would generally protest against the unfair and one-sided contracts and specifications which are more often than not offered for them to bid upon. But it is too often the case that the contracting busi-

ness is not carried on in a wholly open and above-board manner. It very frequently happens that contractors of large political influence actually prefer to have contracts so drawn that the burden of risk and uncertainty falls on the contractor. With such contracts the man without a "pull," the small bidder with nothing but energy and industry and ability in organization, dare not risk the chance of having his small capital wiped out. This throws the business into the hands of those contractors who are "on the inside" and who rely upon their influence with the public officials to be saved from the losses that might ensue if the specifications and contract were enforced to the letter.

An excellent illustration of the way the public is fooled by the over-stringent public contract that seems on its face to be drawn with great zeal to protect the city's interest, comes to us from Chicago. In that city a Commission has been investigating the letting of city contracts. The Chicago "Record-Herald" of Dec. 3 explains the operation of the stringent contract system in an article from which we reprint the following extract.

The commission sees much food for reflection in the bids on which the contracts were let. They are said to be away below the prevailing market prices, and they are considered highly illustrative of the scheme of contract grabbing as described by Joseph Medill Patterson, Commissioner of Public Works under Mayor Dunne. Mr. Patterson said that the manner in which competition is stifled is to draw the contracts stringently, then if a favored dealer got the contract, his inspection was lax, while if some one else got the contract the inspection of his deliveries was made stringent.

The investigators give this point by showing the difference between the contract prices for lumber for the city and the market prices, the following table indicating the range on the various classes of lumber:

	Range of contract prices.	Range of market prices.
John E. Burns Lumber Co., common solid oak	$30 to $35	$35 to $40
Edward Hines Lumber Co., white pine	20 to 30	30 to 40

Norway pine $5 lower.

If the contractors were forced to keep up to specifications, the investigators point out, the prices would be ruinous to them, and the only way in which they can make the contracts profitable is through lax inspection on the part of the city and by the delivery of inferior material. By slashing the prices, it is further pointed out, the favored dealers kill off competition, get a monopoly on the city business and then trust the rest to the sleepiness of the city officials and the laxity of inspection, thus getting the city coming and going.

It will be perfectly evident, from what has been said above, that where such conditions obtain in the contracting business, no legitimate association of contractors can be organized. The contracting business is thrown into the hands of a few "insiders." Others engage in it at their peril. The competition for the protection of the public, which the public letting of contracts is supposed to furnish, degenerates to a farce.

On the other hand, if a regular association is formed of the contractors engaged in legitimate business in any city, its first object will naturally be to effect what this association is seeking to effect in New York. Such an association will inevitably exert its influence to put the contracting business on a sound, safe and honest basis, where all contractors will stand on equal footing, and where any man can bid on a piece of work with reasonable assurance that he will receive honest treatment and a square deal in carrying it out.

LETTERS TO THE EDITOR.

The New Piers of the B. & O. Susquehanna River Bridge; A Correction.

Sir: The article in Engineering News, Nov. 18, 1909, p. 546, on the "Pneumatic Caissons on the Baltimore & Ohio R. R. Bridge Across the Susquehanna," is inaccurate and unfair in its statement that "it was necessary to build several large and deep concrete piers to replace the old ones."

The original bridge was a single-track structure with a number of 480-ft. and two 380-ft. spans, and it is probable that the spacing of the piers was proper for a single-track bridge at the time it was built. The bridge is being renewed with a double-track structure, and investigations showed it would be more economical to divide several of the long spans. This was done with four of the 480-ft. spans and one of the 380-ft. spans, so that it was necessary to construct additional piers, not to "replace the old ones."

The only pier which was rebuilt was the low shore pier on the west side of Garrett Island which was considered too light for the new double-track structure.

Yours truly,
H. R. Talcott,
Engineer of Surveys, B. & O. R. R. Co.

Baltimore, Md., Dec. 4, 1909.

The Project for a Boat and Barge Line on the Missouri River.

Sir: We have read with much interest the report on "Present and Prospective Commerce of the Mississippi River," and editorial bearing on waterways, in your issue of Nov. 4. Your argument is correct, and while it is true that waterways as routes for transportation in comparison with railways have many disadvantages, they have sufficiently strong advantages to be made use of.

Navigating the Missouri is purely a matter of the right type of boats and barges, and of adequate terminal facilities. The former we can obtain without trouble, the latter we realize will be difficult to develop. In other words, we have a great work ahead of us, not only in the problem of navigation, but in getting Kansas City and other important points on the river to develop harbors, ship havens and adequate dock facilities. This work will undoubtedly be of great interest to the engineering fraternity of the country.

We enclose herewith samples of our literature for your inspection. We do this so you may understand this movement of Kansas Cityans to revive river traffic on the Missouri.

This is a great public enterprise for demonstrating to the Government that the channel of the Missouri can be profitably improved, relieving traffic congestion at this point, and developing terminal facilities to meet the needs of shippers.

Yours very truly,
Kansas City Missouri River Navigation Co.

Commerce Building, Kansas City, U. S. A., Dec. 10, 1909.

[The literature enclosed with this letter shows that the company named is appealing for popular subscriptions to one million shares of preferred stock at $1 per share. Walter S. Dickey, the proprietor of the W. S. Dickey Clay Mfg. Co., of Kansas City, is President of the enterprise.—Ed.]

An Example of Specifications Unfair to the Contractor.

Sir: As an example of the unfairness of some construction specifications the writer respectfully submits the following extracts from the contract for the construction of a large drainage ditch in Iowa, bids on which are now being asked for:

The work as a whole will be constructed by and at the expense of the aforesaid Drainage District, under the drainage law . . . the board of Supervisors of _____ County having general supervision of the work, but the detailed supervision of the entire work, including also such lateral drainage or other auxiliary work as may be found necessary to provide for as the work of construction progresses, will be in charge of _____ _____, Civil Engineer, of _____, Iowa (or his successor to be appointed by said Board in case of his death or dismissal), who has been duly appointed by the said Board as construction engineer of the work, and to whom all questions relating to plans of construction, or carrying on of the work, or construing the intent or meaning of these specifications, shall be referred, and in such matters his decision shall be final and binding upon both parties.

So far well and good, but note the following clause, which occurs farther along:

. . . upon the final completion of the work as a whole that is embraced in this contract, the Engineer shall so report to the Board of Supervisors who shall thereupon inspect the work and if satisfactory shall formally accept the same and order payment in full to be made to the contractor, but in case the Board decides that additional work is necessary to properly complete the contract, they shall notify the contractor of the places where the work shall be done and the character and amount required, and the engineer shall at the same time make note of these requirements and see that they are carried out within a reasonable time, and on completion he shall again notify the Board that they may duly receive the work, and upon final completion of the contract the Engineer shall make a full report to the Auditor . . . and upon the filing of said report and acceptance of the work by the Board of Supervisors the Auditor shall then issue a warrant to the contractor for the full amount due him.

In further explanation it should be said that this work will be done with a floating dredge; that the contract provides that at such points as the line of the ditch crosses county highways, bridges will be built by the county with as little delay as possible after the dredge has passed; and that if the said Board, after having provided that the decision of the engineer on all questions connected with the construction of the work shall be "final and binding upon both parties," should find places where, in spite of said Engineer's binding decisions, the ditch is not, in their opinion, fully completed in accordance with the plans and specifications, it will be necessary for the contractor, in order to make the repairs called for, either to remove bridges of some 50-ft. span in order to get back with the dredge beyond them, or to do the work, much of which will be under water, by other methods.

Respectfully yours,
Edward H. Cowan.

Luverne, Iowa, Dec. 1, 1909.

The Interference of Wells.

Sir: The article by Mr. F. G. Clapp on "Interference of Wells" in your issue of Nov. 4, 1909, reminds the writer of a problem that confronted him about nine years ago in Arizona.

The problem was to make out the order for 8-in. column pipe and pump rods for two 12-in. wells about 600 ft. deep, 22 ft. apart, in sand and gravel. The water rose to within 100 ft. of the surface and there were no other wells within a mile. The ground was sloping about 2% toward an Arizona wet-weather stream a mil away.

The first well had been drilled and tested by pumping and found to yield 8,000 gals. per hr. on a 24-hr. test without diminution when the pumping rate was kept up to the point of just not sucking air. The column pipe during the test was long enough to put the foot valve 140 ft. below the surface.

The well derrick was then immediately moved and the second well drilled and pumped. As the ground was easy, the well was soon finished and it also gave 8,000 gals. when tested in the same way as the first well.

It was desired to get at least 16,000 gals. per hr. from the two wells and the question asked was how much lower down should the permanent pumps be located than the above-mentioned 140 ft.

The question was answered as follows: When standing over night without pumping, the water level in both wells was 100 ft. below the surface.

When pumping No. 2, water came up mixed with air when the rate of 8,000 gals. was maintained 24 hrs. (foot valve in No. 2 being 140 ft. below the surface of the ground). When this steady condition had been reached the water level in No. 1 (in which there was no pump) had sunk to 125 ft. below the surface.

The following assumptions were then made: (1) That since the strata were uniform, Well 2 would have yielded 16,000 gals. if it had been pumped down till the water stood 180 ft. below the surface of the ground, and that when pumping Well 2 at this rate the water level in Well 1, in which there was no pump, would have sunk to 150 ft.

(2) That when No. 2 was pumping at 8,000 gals. the water level in the ground half way between the wells would be about 132.5 ft. below the surface of the ground and that had No. 2 been pumped at 16,000 gals. (by using column pipe and rods 180 ft. long) then the water level in the ground half way between the wells would have been 165 ft. below the surface.

(3) That this depth of 165 ft. below the surface of the ground would be the level of the water in both wells when each was yielding 8,000 gals., that is the two jointly yielding 16,000 gals., and being pumped simultaneously.

The column pipes and pump rods were accordingly ordered of such length that the foot valve of the deep well pumps were just 165 ft. below the surface of the ground.

Yours truly,
Buckner Speed.

2425 Hearst Ave., Berkeley, Cal., Nov. 18, 1909.

[It would be interesting and perhaps instructive to know how correct the assumption made proved to be when both wells were connected with the pumping plant.—Ed.]

ELECTRIC WIRING IN NEW YORK CITY (interior work) must hereafter conform in general to the National Electrical Code, promulgated by the National Fire Protection Association and recognized as the country-wide standard. Mr. J. H. O'Brien, Commissioner of the Department of Water Supply, Gas and Electricity, has announced the withdrawal of the main interior-wiring rules of the city and the substitution of the National Code with such slight changes as were demanded by local ordinances and conditions. No change has been made in rules for exterior work and none will be made until an investigation has been completed on the harmonizing of these sections of the city rules and of the National Code.

A STEAMER STRUCK THE BRIDGE over the Chicago River at Madison St. on Nov. 25, causing such damage that the bridge will be out of commission for some weeks. In the meantime a small steamer has been put in use by the city as a passenger ferry, in consequence of the heavy traffic on Madison St. This ferry service was started Dec. 10.

The Construction and Equipment of a Modern Boiler-Making Plant.*

By E. R. FISH.†

In the building of a new boiler plant there were some interesting features which may be of service to others connected with work of this kind. The plant is that of the Heine Safety Boiler Co., at St. Louis, occupying a site of 6½ acres at the intersection of East Marcus Ave. and the Terminal Ry. It was necessary to excavate the higher part of the site and to fill the lower part, and there was sufficient excavated material to fill the area required for immediate use, leaving a considerable area for the future disposition of cinders, etc. A stream crossing the site was straightened, but eventually a city trunk sewer will be built along the course of the stream so that the entire area will be available. On two sides a buttressed retaining wall of reinforced-concrete is built and is 4 ft. inside the property line, so as to keep the wide footings within the site. It has a maximum height of 19½ ft. at the corner, and is stepped down to follow the slope of the hill. This wall forms a part of one of the buildings.

GENERAL PLAN.—The location of the buildings is shown in Fig. 1. It is believed that they are sufficiently large to provide for several years' development, but when conditions require, they may be extended. The office building is a sufficient distance from the shops to avoid serious interference due to the noise.

There are two spur sidings from the Terminal Ry. One of these enters the main shop and is the shipping track. The other passes along the outside of the main shop, and is the receiving track. Another track may be placed along the opposite side of the main building when conditions demand. A 100-ton 42-ft. track scale is located on the railway, near the connection to the spur tracks.

In general the raw material is received at the right-hand end of the main building, that being the storage space. During the manufacturing processes it passes without reversal to the opposite end, where the completed boilers are stored and shipped. Tubes, not being needed until boilers are assembled, are received and stored at this end. The whole floor area of both main and flange shops is served by large or small overhead traveling cranes, while an industrial railway of 24 ins. gage encircles the structure and has connections with interior lines, so that the handling of material of all kinds may be carried on with the least expenditure of time and energy. A portion of the interior of the main building is partitioned off as a machine shop for the little work of that nature required in the manufacturing processes, and to care for the ordinary repairs and maintenance of the plant.

TYPE OF BUILDING.—The buildings are all the same general type and all structural details are standardized as far as practicable. It was determined to eliminate the fire hazard, and to build durably, and yet have a maximum of natural light in the interior, which meant large window space. Steel frame structures were adopted, with outside walls of brick, reinforced-concrete slab roofs, and with full-length monitor roofs in order to obtain additional light and ventilation. About 75% of the vertical areas (exclusive of the retaining walls) is glass. One size of window pane is used throughout, this being a commercial size, 12 x 16 ins. The advantage of this will be appreciated when it is understood that there are over 22,000 panes in the several buildings. Wood is used only for window and door frames, doors, and the machine shop floor. The view, Fig. 2, shows the arrangement and appearance of the buildings.

MAIN SHOP.—This is 450 ft. long, 143 ft. wide for 250 ft. of its length and 180 ft. for the remainder. The narrower portion is divided into three longitudinal bays, the middle one being 60 ft. wide and the others 41½ ft. The increase to 180 ft. is made by the addition of a fourth bay of 37 ft. The design of the steel frame follows standard practice, being calculated for the dead and live loads imposed by the roof and traveling cranes, the runways for which are 9-in. I-beams hung to lower chords of the roof trusses. The runway of the large crane, however, is carried directly on the main columns. The roof trusses are spaced 12½ ft., and are carried on columns. Fig. 3 is a view of the steel frame, showing the 25-ft. spacing of columns and 12½-ft. spacing of trusses.

The columns of the central bay are spaced 25 ft. longitudinally and 60 ft. transversely, and carry the runway for the 25-ton traveling crane. The spacing of the trusses thus provides stiffeners at the center points of this runway and provides spans of only 12½ ft. for the support of the smaller runways in the side bays. The roof of the middle bay is 14 ft. higher than that of the side bays, thus forming the monitor in which the principal crane runs. About the middle of the side toward the power-house is the riveting tower, 100 x 24 ft., its roof being 55 ft. above the floor. This is shown in Fig. 2. The steel work of this tower is framed into that of the building.

The outside walls are of brick with concrete footings, and completely enclose the outer steel columns. The outside columns carrying the trusses of the fourth bay rest on the retaining wall, which also serves as a foundation for the brick walls that close the end and side of the building at these points. Practically all the windows (in all the buildings) are 9 ft. 8 ins. x 17 ft. 5 ins. Their stone sills are 3 ft. 2 ins. above the floor line, while the tops are practically at the height of the lower chords of the roof trusses.

Each window has two vertical rows of three sashes, each 3 ft. 5 ins. x 5 ft. 10 ins. The middle sash is stationary; the upper and lower sashes are arranged so that they can be raised and lowered vertically. They counterbalance each other through steel chains over pulleys at the top of the window frames, so that by raising the lower sash, any degree of opening of the windows to 66% is easily and conveniently accomplished by one man and from the floor level. The windows over the retaining walls at the rear end and side are arranged so as to utilize as much of the space between the top of the wall and the roof trusses as is practicable.

Both sides of the monitor are practically all window space, there being two rows of sashes which are each 3 ft. 5 ins. x 5 ft. 10 ins. The lower sashes are stationary; those of the upper row are pivoted at the middle so they can be opened for ventilating purposes. One side of this monitor is unbroken, but the opposite side is divided into two sections by the riveting tower. Double rows of windows arranged similarly to those in the monitor are placed in both sides and end of the tower. The pivoted windows in each side of the monitor are operated in two sections of equal length, each by means of a single window-operating device. The upper row of sash on two sides of the riveting tower is likewise pivoted and operated.

The standard size of door opening is 9 ft. 8 ins. x 12 ft., closed by two equal swinging doors, one of which contains a small door for employees. Above these doors are two stationary window sashes of standard size. In the receiving end of the building a special door opening (A) 22 ft. 2 ins. x 20 ft. The [illegible] this is carried a transverse craneway 18 ft. 8¼ in[illegible] span, projecting outside the building over the receiving track; the outer end is carried by A-frames. This connects with the longitudinal cranes on the inside, thus permitting the unloading of material from cars expeditiously and cheaply.

This large opening is closed by means of a [illegible] steel door carried on trolleys which run on the crane way. The carriage for the door is covered with a hood which entirely closes the opening above and between the beams when against the building, the door and rolling mechanism being suspended below the craneway beams. When in this position the rolling door lowers into the guides provided at the sides of the opening. When it is entirely rolled up, the whole carriage may be removed to the outer end of the craneway, as shown in Fig. 4. It thus gives an unobstructed passage for the traveling crane, and at the same time preserves the continuity of the craneway.

This special door was made necessary by the extreme size of the opening and by governing conditions which rendered any other type of door impracticable. The door and carriage are operated by means of gears and hand chains. The hood so protects the mechanism of the carriage and the door when it is rolled up that it can be left exposed at the outer end of the craneway without harmful results. Although the door is of large dimensions it can be opened and closed by one man, even in a high wind. A door (B), 14 x 16 ft., is provided in the end of the fourth bay to permit the placing of cars inside the building when the proposed siding on that side is built.

The roof is a 2½-in. concrete slab reinforced with wire mesh and carried by 6-in. I-beam purlins placed 5 ft. apart on the top chords of the roof trusses. This is covered with two-ply tar felt and gravel laid in hot asphalt. Two transverse expansion joints divide the roof into three equal sections 150 ft. long. These joints

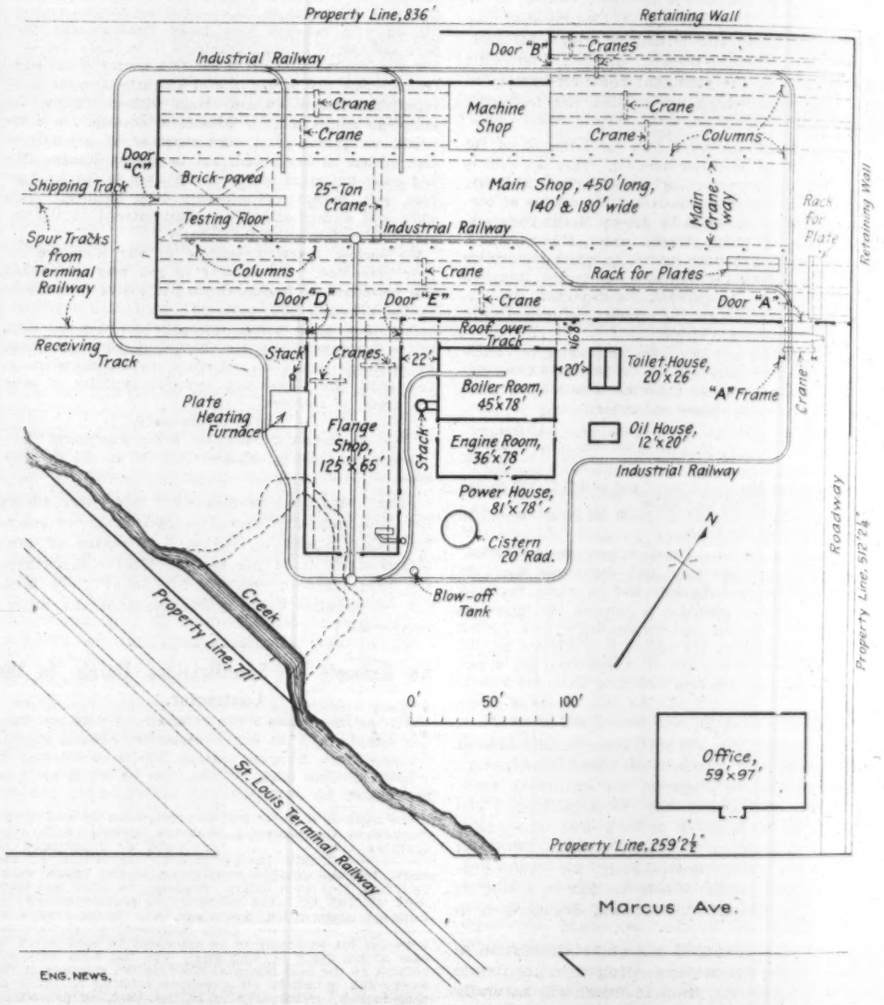


FIG. 1. GENERAL PLAN OF THE NEW PLANT OF THE HEINE SAFETY BOILER CO.: ST. LOUIS, MO.

(Showing the arrangement of the buildings, traveling cranes, railway sidings and industrial railway.)

*Abstract of a paper read at a joint meeting of the Engineers' Club of St. Louis and the St. Louis branch of the American Society of Mechanical Engineers, Nov. 13.

†Secretary, Heine Safety Boiler Co., St. Louis.

are flashed with copper. The gutter troughs and downspouts are of copper, supported by galvanized iron brackets set in the brick work. Ample expansion joints are provided in the troughs to prevent buckling or breakages. Each downspout connects with a cast-iron shoe to the underground drainage system so that rain water serves as an auxiliary water supply.

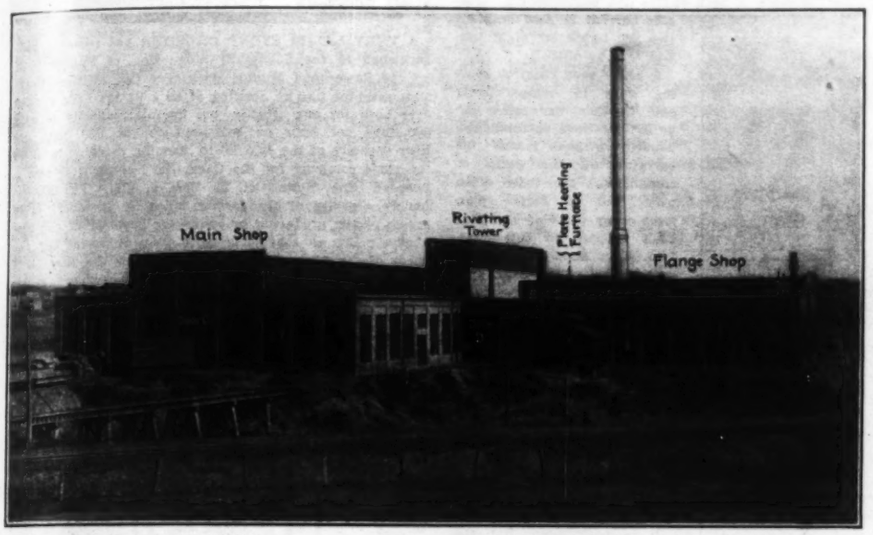


FIG. 2. GENERAL VIEW OF THE BOILER MAKING PLANT.

The exposed sides of the riveting tower are 4-in. reinforced-concrete slabs to the height of the monitor roof, above which are the windows. The machine shop is formed by partitioning off a space 40 × 62 ft. with corrugated iron attached to angle iron frames fastened to the building columns. This partition, however, is largely window space. Where the flange shop joins the main building the wall has been omitted, giving free communication between the two.

The floor will ultimately be of cinders mixed with a binder of heavy oil residuum, and compacted by rolling. At present it is the natural clay. The machine shop has a heavy plank floor. The shipping track at the front end enters through a sliding door (C), 14 ft. × 16 ft. It holds two cars inside the building, and bisects the testing floor. This is a brick pavement 62 × 76 ft., laid in cement on a concrete base, draining into four sewer inlets which connect with the drainage system, thus returning the testing water to the cistern.

FLANGE SHOP.—The construction is similar in every way to that of the main building, to which it is connected, the end wall being omitted so that the two structures are practically one. The steel frame consists of a row of columns in each side wall spaced 25 ft. apart and carrying the roof trusses. Intermediate trusses make the spacing 12½ ft. These trusses span the entire width of the building, leaving the floor area unobstructed, and carry two craneways of 9-in. I-beams with 18 ft. 8 ins. span. These are hung from the bottom chords, below which there is a clear height of 20 ft. This building has a monitor 13 ft. wide and 9 ft. high, made of light frames supported by the roof trusses. The window arrangement is the same as in the main building, except that the monitor has but one row of pivoted sashes on each side, connected to a window-operating device.

Door openings (D and E), 16 ft. 10 ins. × 20 ft. 9 ins., are placed in the side walls at the ends next the main building through which the receiving track passes. These openings are closed by rolling steel doors, so that cars can be operated through the building on this track. In one side of the building an opening is left in the wall for the large heating furnace which is housed outside in a small steel frame structure.

One of the outer corners of the shop is over a fill and a part of the original creek bed. This made it necessary to carry foundations down 24 ft. to bed rock. These are concrete columns, carrying reinforced-concrete beams just below the floor level, which in turn carry the steel columns and the brick walls.

POWER-HOUSE.—In the main the construction is the same as in the other two buildings. It is divided into an engine room (34 ft. 7 ins. wide) and boiler room (42 ft. 11 ins. wide) by a brick wall, in which is located a row of columns carrying the abutting ends of the roof trusses. The monitor, 13 ft. wide and 50 ft. long, with windows as before described, is half over one room and half over the other, the partition wall extending to its roof. The middle and outer rows of columns carry the runway of an overhead traveling crane serving the engine room. The roof is continued over the space between this and the main building in order that coal cars may be unloaded without interference by the weather. The entire floor of this building is at the same level, made of concrete and provided with necessary pipe trenches, which are covered with iron plates.

OTHER BUILDINGS.—The toilet building is a one-story brick building with a concrete roof and floor, and divided by a brick wall into two rooms about 9 ft. wide. One room contains ten wash-down closets and an iron enameled urinal, both with automatic flush. White enameled wash sinks with numerous hot and cold faucets are in the other room. A galvanized house boiler, heated by exhaust steam, furnishes a supply of hot water. Lighting is by small windows near the top of the walls. The sewage is carried to the creek, which will give place to a sewer eventually, as already noted.

The oil house is a one-story brick building with a concrete roof and floor. It is intended solely for the storage of inflammable liquids, etc.

SHOP EQUIPMENT.—In the main shop are stored all the raw material, supplies, etc., Most of this storing is at the extreme rear end and side where there is the least light, yet where the material is accessible and easily removed to any point where it may be needed. A 3-ton traveling crane on the transverse craneway heretofore mentioned serves the delivering track and places the boiler plate (which is the heaviest material received) directly into a series of racks that hold the plates in a vertical position so that any plate may be withdrawn without unnecessary handling. The side bays are each served by four 3-ton 14-ft. traveling cranes with hand operated triplex blocks running on two adjacent parallel craneways in each bay, hung to the bottom chords of the roof trusses. Most of the tools in the main shop are driven by individual electric motors, and the machine shop equipment is driven by belting from a line shaft. Under the riveting tower are two 100-ton hydraulic riveters and a 30-in. horizontal punch; these are served by three 10-ton hydraulic traveling tower cranes of 20½-ft. span and 40-ft. lift.

All the small traveling cranes in both shops on adjacent parallel tracks overhang their runways far enough so they can be locked together and the trolley run from one to the other.

All the steam, hydraulic and air pipes and electric wires are brought over from the power-house in covered trenches, and are so arranged that they can be easily drained in cold weather to avoid all danger of freezing. The air pipes have numerous connections at convenient points throughout the main shop, flange shop and machine shop.

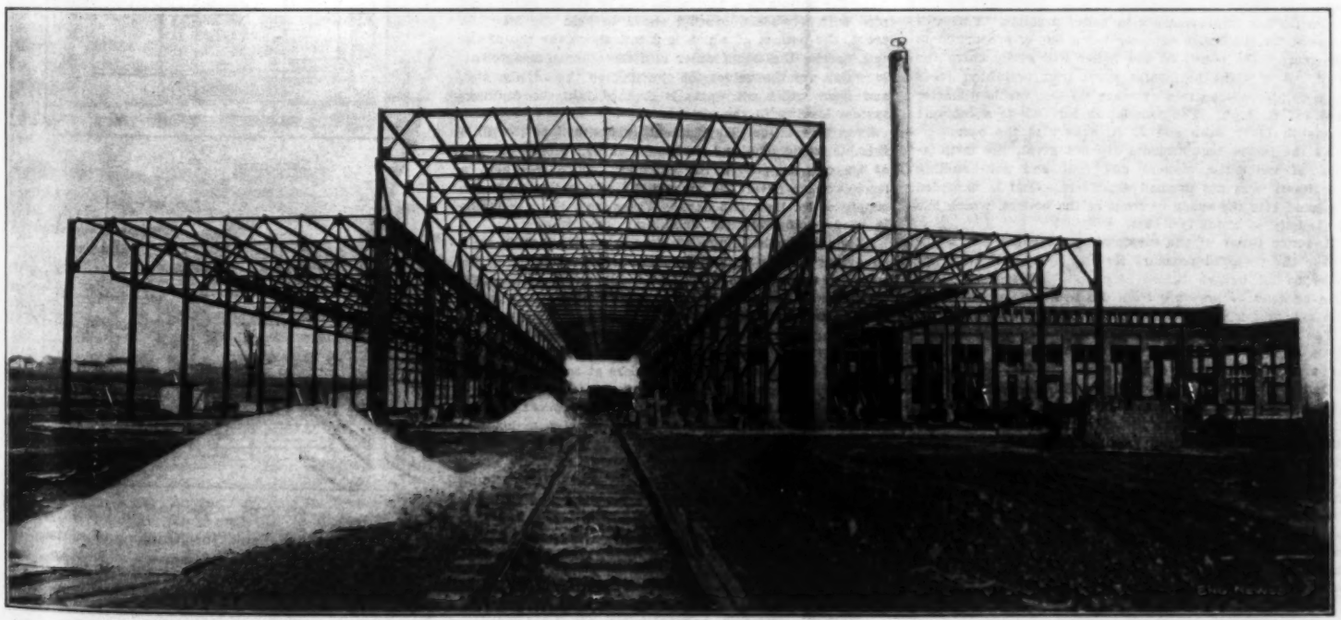


FIG. 3. THE STEEL FRAMING OF THE MAIN SHOP; COLUMNS 25 FT. APART, ROOF TRUSSES 12½ FT. APART.
(The building at the right is the flange shop.)

POWER PLANT.—All the generating machinery is located in the power-house, which is placed in close proximity to the hydraulic and pneumatic tools, in order to reduce the length of the transmission lines, saving both in first cost, frictional losses and maintenance. The great majority of the tools are electrically driven, by individual motors whenever practicable.

The boiler plant consists of three Heine boilers of 250 HP. each, set separately. Two of them are provided with Heine superheaters. They are all fired by hand and have flat shaking grates. Back of the bridge walls of each furnace is a special firebrick wing-wall construction for the prevention of smoke, and this accomplishes its object very satisfactorily. The two boilers with the superheaters are set in brickwork in the usual way. The third boiler has a concrete setting with firebrick lining. This is an experiment to determine the availability of concrete construction for this purpose, and with the expectation that it will be more durable than brick and less liable to crack.

The company has in view a great variety of experiments to determine questions now in doubt and to develop further improvements in boiler practice. This will account for the boiler capacity being out of proportion to the rest of the plant, as one boiler will easily carry the load. A straight horizontal sheet iron breeching leads to a reinforced-concrete chimney 66 ins. inside diameter and 147 ft. high. The foundation for this is a concrete monolith 11 ft. deep and 22 ft. square at the base.

As the power requirements are not great, the installation of automatic stokers and coal and ash-handling machinery was not deemed expedient. Coal is unloaded by hand into the space in front of the boilers, which has a capacity of about two cars.

A boiler tester of the injector type supplies hot water under the required pressure for the hydrostatic test applied to all boilers before shipment. This testing can also be done by pressure from the hydraulic system, and through proper connections by the boiler feed pumps.

The electrical energy is developed by a three-phase, 60-cycle generator of 100 KW., 220 volts, directly connected to a non-condensing engine. A 16-KW. exciter is belted to a pulley on the engine shaft. The other equipment includes (1) a two-stage compound non-condensing air compressor (1,200 cu. ft. of free air per min. at 100 lbs. pressure); (2) a duplex compound non-condensing engine for the hydraulic system, with a capacity of 100 gals. per min. against 1,500 lbs. pressure; (3) an hydraulic accumulator with 12-in. ram and 15-ft. stroke, loaded to 1,500 lbs. per sq. in. Space is provided for an additional generating set and hydraulic pump. The air supply for the compressor is brought from the roof through a 12-in. sheet iron-duct to an air-washer placed behind the boilers.

Means are provided for filling boilers directly with city water. The suctions of the feed-pumps are connected to the feed water heater, the city mains and the rain-water cistern. As far as practicable all water is saved, to effect which a drainage system is provided into which all rain water from the roofs as well as the clean waste from manufacturing processes is discharged. This system discharges into a cement lined cistern 20 ft. diameter and 20 ft. deep near the power-house. As the only other source of water supply is from the city mains this arrangement effects a very appreciable economy.

FIG. 4. REMOVABLE ROLLING DOOR AT THE RECEIVING DOORWAY.
(The door, with its carriage, hood and operating mechanism, is shown run out to the end of the craneway to leave the opening entirely clear.)

MISCELLANEOUS.—Artificial lighting is mainly by 10 flaming arc lights uniformly distributed through the shops. They are hung to clear the cranes in monitor and bays, and in the latter are about 22 ft. from the ground. The engine and boiler room have each one lamp of the same kind. In addition, each machine tool has one or more incandescent lights. Special six-light incandescent fixtures are recessed in the walls (10 ft. from the floor) around the sides of both engine and boiler rooms. Outside current is used only for two arc lights for night use, and for the office.

A boiler shop requires heating only in comparatively cold weather, say below 45° or 50° F. Open salamanders, usually without means for carrying off the gases of combustion, are most often used, but a better plan from every point of view has been adopted in this case. The main shop is provided with a sort of hot-blast system, consisting of five sets of enclosed coils of ¾-in. pipe each containing about 3,000 sq. ft. of radiating surface. A motor-driven fan forces the air through the coils, discharging directly into the room in an opposite direction from the intake. These sets are distributed so as to give the greatest heating effect where needed.

It is anticipated that the circulation thus created will make the temperature sufficiently high and as nearly uniform as is necessary. Exhaust steam is used, but whether there will be sufficient and whether the system will be satisfactory, has yet to be determined. The machine shop, toilet house and office are heated by direct radiators. The flange shop needs no special heating the fires there being ample. If there proves to be insufficient exhaust steam for the heating system, live steam will be turned in through a reducing valve.

To provide cool drinking water in summer, a special drinking fountain (Fig. 5) was designed. Two of these are installed. Each consists of a concrete-lined pit about 4 × 6 ft. and 3 ft. deep; divided into two compartments, 27 × 27 ins. and 18 × 37 ins. The walls of the larger, which is the ice chamber, are built with air spaces. Near the bottom is a horizontal coil of 1¼-in. galvanized pipe with a wooden grating above to hold the ice. A drain, the bottom of which is 2 ins. above the top of the coil, carries the warm water into the other compartment, in which are the valves for shutting off the supply, etc., and from which all waste is drained into the drainage system leading to the cistern.

Over this latter compartment is the hydrant, with a suitable waste pipe and perforated cover. About 300 lbs. of ice can be put in the chamber, which has both a thick wooden cover and an iron lid. In hot weather the supply of ice lasts two days. Water from the city mains is used exclusively for drinking.

Although the buildings are free from fire risk to such an extent that it is considered unnecessary to carry insurance, there is more or less inflammable material in the shape of boxes, barrels and other packing material, as well as wooden railway cars. A simple fire system was therefore installed. Six 2-in. fire hydrants are distributed through the main shop, with 100 ft. of canvas hose and nozzle suspended on holders at each. There are also three hydrants outside, two on opposite sides of the front end of the main building and one near the oil house. The water supply is from the city mains and under a pressure of 60 lbs., so no other source of supply for this purpose is necessary. In addition there are 9 non-freezing and 24 dry-powder fire extinguishers hung at convenient points. There is a city fire-alarm box on the outside of the power-house.

COSTS.—The land was purchased in the middle of 1907 and the general scheme worked out by the officers of the company in conjunction with Lichter & Jens, Consulting Engineers, who drew the plans and superintended the work. The construction was purposely undertaken at a time of business depression. Owing, however, to the very limited building operations at the time, it was certain that the first cost would be very low, and early in 1908, when materials were at their lowest prices, it was determined to proceed.

The grading was done in June and July, 1908. A little more than 18,000 cu. yds. of earth was excavated at a cost of 16 cts. per cu. yd. The steel work, amounting to about 790 tons, was furnished by the Riter-Conley Mfg. Co. at the rate of practically 2.6 cts. per lb. f. o. b. St. Louis. The erecting of the steel was done by the Midland Erection Co. at the rate of $8.80 per ton. The general contract for the completion of the main shop, flange shop and power-house was executed by the Fruin-Colnon Contracting Co. The total cost of these buildings was $1.15 per sq. ft. of floor area, excluding the retaining walls and grading, and $1.25 including those two items. This, of course, does not include any of the equipment.

A VERY LARGE STONE CRUSHER has recently been furnished to the Schuylkill Stone Co., of Philadelphia, by the Power and Mining Machinery Co., of New York. This machine has an opening of 60 × 84 ins., the largest ever built for any crusher, but its total capacity is only 600 tons per hour as compared to the 800 tons per hour capacity of the 42 × 96-in. opening machine built by the same company for the Gary, Ind., plant of Dolese & Shepard (Eng. News, Oct. 21, 1909, p. 427). The 600-ton hourly capacity of the former machine, however, is in excess of the producing or conveying capacity of the rest of the plant, so that it is more than sufficient for the needs of the works. Its special feature is the very large opening, which will handle, without any previous blasting or breaking, any rock capable of being carried by a steam-shovel.

The plant of the Schuylkill Stone Co. has a number of points of interest. The material to be crushed is a trap rock, and the large crusher breaks the stone down to 10-in., which runs directly to a No. 10 and two No. 7½ crushers; it is then elevated in a 60-in. pan conveyor to two large scalping screens 84 ins. diameter × 15 ft. long. The screen perforations the entire length of these screens are 3-in. holes. All of the product going through the 3-in. perforations is discharged by gravity to two 60-in. × 16-ft. screens. The first 6 ft. of screen perforations on these screens is 2-in. holes, and the balance of the screen is 2½-in. holes. The material running out the end screens is material that has already passed a 3-in. ring, a ballast size. There is no oversize stone, as all of this material has already passed the 3-in. perforations in the scalping screens. All of the material passing through the first 6-ft. section of 2-in. perforations is discharged by gravity into two 60-in. × 24-ft. screens which make four separations of stone down to ¼-in., the 24-ft. screens having 10-ft. dust jackets at the head end. The oversizes from the 84-in. × 15-ft. screens are returned by gravity to two No. 6 and two No. 7½ crushers. This company has large ballast contracts which they are supplying with the crushed stone from this plant.

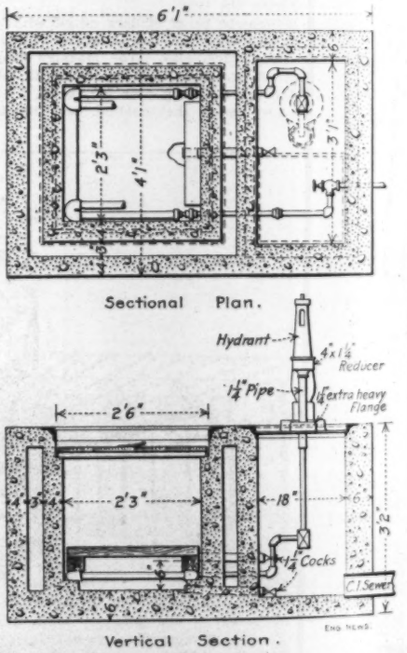


Fig. 5. Cooling Tank for Drinking Fountain in Boiler Shop.

The plant is operated by cross compound Corliss engines, and there is a separate power plant for generating electricity for lighting the crusher house and quarries for night work. There is also a complete belt conveyor system and ground storage for 20,000 cu. yds. of stone. Material is taken from the crusher bins and stored on the ground, and a 600-ft. conveyor runs under the storage piles so that any size stone can be drawn from the piles and carried to a switch nearby where it is loaded on cars.

Data Relating to Awards for Water and Water-Power Diversion.*

At the convention of the New England Water Works Association held in Springfield, Sept. 12, 1907, a resolution was passed "that a committee of five be appointed by the president to collect data relating to awards that have been made for damages resulting from the diversion of water; also to consider the practicability of joint action with the National Cotton Manufacturers' Association, or other organizations of mill owners, relating to the formulation of standard rules of computing or assessing damages for the diversion of water."

Pursuant to this resolution, the president appointed the following committee: Charles T. Main, Boston, Mass.; Leonard Metcalf, Boston, Mass.; Richard A. Hale, Lawrence, Mass.; Charles E. Chandler, Norwich, Conn.; William Wheeler, Boston, Mass. The committee met and organized with Charles T. Main as chairman and Leonard Metcalf as secretary.

After a careful consideration of the duties of the committee in their broader aspect, the committee decided to include in its search for statistical data relating to the diversion of water or water power, not only awards which had been made therefor by different tribunals, but also such records of sales of the right to divert power as it might be able to learn of.

A printed circular was sent out to all members of the association, and to many water-works superintendents and engineers in different parts of the country. This circular was followed by several hundred personal letters addressed by the secretary to water-works men and engineers in different parts of the country and in Canada, who it was hoped might contribute data. Subsequently, several hundred letters were sent out as second and third requests for information.

The committee recognized the difficulty of its task, for data of this sort are soon buried in the files of the interested parties, or their lawyers or experts, and the assembling of the information asked for made a serious demand upon the time of the men addressed. Moreover, in many cases it was recognized that publicity would neither be desirable nor permitted. In all such instances the committee has urged that the information be given in outline, so that the basic facts might be known, without giving the names or the details in such form that the location could be recognized.

It is also perhaps worthy of note that litigation over such cases has been limited almost wholly to the Atlantic or Eastern states, and that little if any information could, therefore, be obtained from other parts of the country.

Scope of Inquiry.

While a considerable amount of data, which it is still hoped may be contributed hereto as discussion, has not yet been received, your committee has thought it wiser to present its final report at the present time rather than to postpone its presentation until a later date; but any material which may be presented in the discussion of this report will be incorporated in its final publication in the "Journal" of the association.

In the fundamental data which follow but one series of facts stated is the work of the committee—the computation of the unit basis of award or agreed selling price; that is, the amount thereof "per square mile per foot of fall," or "per million gallons daily per foot of fall."

UNIT BASIS OF COMPARISON ADOPTED.—Why, it may be asked here, did your committee select the unit basis adopted for comparison of the information contained in these circulars?

Direct comparison was impossible for obvious reasons. A comparison of the amount of the awards or the prices agreed upon could not be compared upon a horse-power basis without involving questions as to the character of the use, the hours of use (whether for 24-hour power, 10-hour power, or any other period), and without the exercise of judgment by the committee or of the experts employed upon the different sides of the case.

For this reason it seemed wiser to your committee to adopt as a standard unit of comparison in these cases the amount "($) per square mile per foot of fall," or "($) per million gallons daily per foot of fall." These standards are relatively fixed and easy of determination, for there is usually substantial agreement by the experts as to the extent of the watershed involved and the actual available fall. It is true that in discussing data based upon this standard the variation in yield from watersheds in different parts of the country must be clearly borne in mind. On the other hand, this variation within the limits of the data submitted is slight as compared with the difference in judgment which would have been found had the horse-power basis been adopted. Attention is also called to the fact that the figures discussed relate primarily to the payments for the water power taken, without allowance for interest upon the award from the date of diversion to the date of award, and without allowance for such items as large adjacent areas of land, mills, tenements, or other buildings, and plant contained therein.

*Condensed from Report of Committee of New England Water Works Association, submitted Dec. 8, 1909.

In figuring the amount of award, or price paid per square mile per foot of fall, the watershed actually diverted is used and not the total amount of watershed above the privilege (unless the entire amount above the privilege was diverted), and the available fall in feet (rather than the fall actually developed or utilized). Similarly, in figuring the unit "($) per million gallons daily per foot of fall," the amount of water the right to divert which was taken was assumed rather than the actual amount of the diversion at the time of the taking. And the result is given usually to three significant figures only, the limit of accuracy.

The fundamental statistics received are submitted in Appendix B of this report [not yet published—Ed.].

SUMMARIZED RESULTS.—For the purpose of more readily making comparison in any desired analysis of the fundamental data, the results submitted in Appendix B have been summarized in the brief form submitted in Appendix A. [Table IV.]

The general range covered by the data accumulated is shown by Table I.

The number of awards per million gallons of water diverted are so few that the reader is referred directly to Table IV. for them.

INTERPRETATION OF RESULTS.—It hardly seems necessary to allude to the fact, which must be patent to any student of this subject, that none of the results submitted can be applied directly to new cases, for the reason that no two cases are identical or even thoroughly similar.

Your committee, therefore, desires to place itself on record in urging caution in the application of the information submitted, and calls attention to a few of the considerations which must be clearly borne in mind in making comparison of conditions.

Among these conditions may be mentioned the method by which the price paid for the water or power diverted was determined, whether by agreement or by legal procedure, the knowledge and proficiency of the interested parties, or those called to their assistance; the market value of the privilege affected; the cost of development; the character of the privilege, if developed; the degree of development; the character of the use of the development; the character of the particular industry and of the industries of the community in which the privilege is located; the labor conditions; the location of the privilege in reference to railroads, water, or other transportation facilities; the yield of the streams in amount, distribution, and constancy, and the storage facilities upon them.

And, finally, in comparing the prices paid, by award or agreement, let the fact not be lost sight of that litigation is expensive, and that while awards may seem high in some cases, the actual financial return to the injured parties after deduction of the cost of litigation may be less even than could have been obtained by agreement without legal procedure. Even agreement implies compromise, and considerable sums of money are often paid by agreement to avoid the expense of litigation.

APPROXIMATE POWER DERIVABLE FROM NEW ENGLAND WATERSHEDS.—Your committee recognizes the danger of laying down approximate rules for determining the amount of power to be derived from watersheds with privileges of known fall in New England. The subject is one requiring the judgment of one well versed in such matters, for different conditions, such as the character of the watershed, its location and elevation, the amount and control of the storage upon it, etc., will materially affect not only the amount, but more important, perhaps, the distribution and constancy of the power to be derived from these watersheds.

For purposes of approximation, and for the benefit of those who may wish to form some general idea of the relation between the yield or flow of streams in this vicinity and the available 24-hour power to be derived from them, the following approximate general rule may be of service:

A yearly average of approximately 0.1 *HP. per sq. mi. of tributary watershed per ft. of fall* (which corresponds to a maximum 24-hour flow or development of water of about 1.4 cu. ft. per sec. per sq. mi. of watershed and a maximum available 24-hour net power of 0.12 HP. per ft. of fall per sq. mi. of watershed) *may generally be obtained economically*, and a correspondingly greater rate of output if the power be used for less than 24 hours per day, and sufficient pondage be available to make such concentrated use of the water possible.

TABLE I.—RANGE OF WATER-POWER PRICES REACHED BY AGREEMENT AND BY AWARD.

	No. of cases.	Value per sq. mi. of watershed per ft. of fall. Max.	Min.	Aver.
Developed privileges:				
a. By award	112	$366.10	$2.45	$81.42
b. By agreement	66	181.20	2.80	54.90
Combined (a and b)..	178	366.10	2.45	71.55
Undeveloped, unused, or abandoned privileges:				
c. By award	10	15.72	0.20	6.22
d. By agreement	11	25.60	1.04	8.15
Combined (c and d)..	21	25.60	0.20	7.26

The yield or flow of water from the Sudbury, Nashua and Croton River watersheds has been carefully observed for a long period of years and has shown the accompanying (Table II.) average results in cubic feet of water flowing per second from each square mile of watershed, arranging the average monthly records of each year in the order of the dryness of those months instead of in the calendar order of the months, and averaging these results, obtaining thus the average for a long period of years of the driest month of each year, of the second driest month of each year, the third driest, etc., to the wettest month of each year.

The Sudbury yields are stated for three different periods:

(1) The 23-yr. period from 1875 to 1897, for the reason that the records of this period are believed to be more precise than the later records, as the water surfaces of the reservoirs upon this watershed were largely increased at this time, and as since March, 1898, an increasing quantity of water has been diverted from the Nashua River through the Sudbury basin, involving the measuring in and measuring out of this flow in addition to observations upon the gain and loss in storage in the reservoirs upon the Sudbury watershed.

(2) The 12-yr. period from 1897 to 1908, the period during which observations have also been made upon the Nashua River.

(3) The entire 34-yr. period from 1875 to 1908.

Attention is called to the fact that the Sudbury River yield records do not give the actual run-off of the river (which would include the effect of storage in the wet season and draft from storage in the dry season from the tributary reservoirs and streams, as well as the loss by evaporation of water from them), but the natural flow of the watershed *without* storage, so nearly as this flow can be measured and adjusted for the change in volume of stored water, but without taking into account the actual loss of water by evaporation from the water surfaces of the existing reservoirs and streams upon this watershed. It may be said that this method of figuring the yield is common in water-works or supply cases, as is the case also in the Nashua and Croton records, but upon streams utilized chiefly for power production purposes the effect of storage as well as the loss by evaporation is included in the yield or run-off measurements and records.

If we assume, further, according to the probable concensus of opinion of engineers:

(1) A wheel development at the water-power privilege being investigated, corresponding to the yield of the tributary watershed in the seventh month, arranged in order of dryness.

(2) Collection of water or yield upon the tributary watershed as shown in the tabulations above, which do not cover the effect of large storage basins, to equalize the flow of the wet and the dry season.

(3) 75% efficiency in the use of water in the development of power, *the resulting net 24-hour power to be developed per square mile of tributary watershed per foot of fall* will be as shown by Table III.

Example: The method of computation is shown by the calculations of the figure for the driest month on the Croton basis, as follows: 1 (sq. mi.) × 0.26 (c.f.s. per square mile) × 62.4 (lb.) × 1 (foot fall × 0.75 (efficiency) ÷ 550 (ft. lb. per second) = 0.0221 HP.

The actual wheel development or installation, which usually materially exceeds the *average* power obtainable, varies with the available water and the portion of the day into which its flow is concentrated, or during which it is used, and some other considerations or factors. In 24-hour power developments in this region the wheel development is perhaps generally designed to utilize from 1 to 1.4 cu. ft. of water per sec. per sq. mi. of tributary watershed, and even more in special cases; in 10-hour power developments an examination of a large number of actual mill installations upon New England streams has shown a development to utilize approximately 1.4 cu ft. of water per sec. per sq. mi. of tributary watershed, corresponding to the yield of the sixth or seventh month, arranged in the order of their dryness, of an average year; or more in special cases, depending upon the amount of available pondage adjacent to the water-power plant or privilege, the character of the industry, etc.

The relation between the amount of water flowing and the horse-power obtainable from it is indicated by the following:

1 cu. ft. of water per sec. per sq. mi. per ft. of fall at 75% efficiency =

$$1 \text{ c.f.p.s} \times 62.43 \text{ lb.} \times \frac{1 \text{ ft. fall}}{550} \times \frac{75}{100} \text{ efficiency} = 0.08133 \text{ HP.}$$

1.25 c.f.p.s. " " " = 0.1064 "
1.4 c.f.p.s. " " " = 0.1192 "
1.5 c.f.p.s. " " " = 0.1277 "

From Table III. it appears that, for purposes of general approximation, we may assume that in New England watersheds *without* a material amount of storage and with a development up to the yield of the seventh month of an average year, arranged in the order of the dryness of those months, there can be obtained an aver-

TABLE II.—YIELD IN CUBIC FEET PER SECOND PER SQUARE MILE OF WATERSHED, SUDBURY, NASHUA AND CROTON RIVERS.

	Sudbury River. (75.2 sq. mi.) (1.9% to 6.5% water surface.)			Nashua River. (118.19 sq. mi.) (2.2 to 7% water surface.)	Croton River.* (360.4 sq. mi.) (4.47% water surface.)
	23-year period, 1875-1897.	12-year period, 1897-1908.	34-year period, 1875-1908	12-year period, 1897-1908.	32-year period, 1868-1899.
Direst month	0.192	0.098	0.160	0.385	0.26
Second driest month	0.271	0.232	0.256	0.557	0.41
Third " "	0.443	0.431	0.420	0.722	0.55
Fourth " "	0.582	0.614	0.551	0.903	0.74
Fifth " "	0.771	0.730	0.741	1.022	0.93
Sixth " "	1.049	0.871	0.976	1.182	1.20
Seventh " "	1.308	1.048	1.210	1.401	1.41
Eighth " "	1.508	1.719	1.644	1.861	1.74
Ninth " "	2.225	2.314	2.273	2.431	2.18
Tenth " "	2.801	2.761	2.800	2.811	2.73
Eleventh " "	3.585	3.610	3.613	3.705	3.41
Wettest month	4.992	4.891	4.939	4.968	4.48
Average	1.643	1.610	1.617	1.829	1.66

*See John R. Freeman's report upon New York Water Supply, p. 240.

age of approximately 0.09 HP. (24-hour p[illegible]r) per sq. mi. of tributary watershed per ft. of fall, the minimum power under such conditions may fall one-third or less of this amount. *With* storage the above-stated available power (0.09 HP.) would be appreciably increased, the amount of this increase depending upon the volume and control of this storage.

In the light of all of these facts, it is perhaps safe to say, as previously stated, *that for purposes of rough approximation for New England watersheds with some storage there can be developed* 0.1 *HP.* (24-hour power) *per sq. mi. of watershed per ft. of fall* but it must be clearly borne in mind, as stated, that local conditions, character of watershed, location and elevation, storage facilities and control, cost, and character of development and industry to be served will modify this figure materially.

FORMULATION OF STANDARD RULES FOR ASSESSING DAMAGES IMPOSSIBLE.—Your committee has considered carefully, as instructed by the original vote

TABLE IV.—SUMMARY OF WATER-POWER PURCHASE DATA COLLECTED BY A COMMITTEE OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

Developed Privileges by Award.

Location.	Watershed, sq. mi. Total.	Watershed, sq. mi. Diverted.	Available fall. ft.	Award (excluding interest, etc.) Per sq. mi. of watershed per ft of fall.	Award (excluding interest, etc.) Per million gals. daily per ft. of fall	Remarks.
Connecticut—						
Cheshire, Ten Mile Brook	5.6	1.6	22.	($198.86)	.....	Unusual storage facilities.
Cheshire, Ten Mile Brook	5.7	1.6	20.	46.87	.....	
Naugatuck, Straitsville Brook	20.	1.8	35.	2.45	.....	
New London, Brigg's Brook	2.	1.6	51.	(95.60)	.....	Including rights of way.
New London, Brigg's Brook	2.4	1.6	....	....	.....	Special case.
Plainville, Pequabuck River	46.4	7.2	15.1	65.	.....	
Waterbury, Naugatuck River	20.	18.	7.	15.90	.....	
Waterbury, Naugatuck River	23.	18.	13.	29.90	.....	
Waterbury, Naugatuck River	23.2	18.	7.	9.52	.....	
Wilton	7.	...	7. (?)	....	.....	Special case.
Windsor, Mill Brook	1.	...	20.	....	$449.00	200,000 g.p.d.
Windsor, Mill Brook	1.	...	9.8	....		
District of Columbia	....	...	....	....	.....	Special case.
Maine—						
Waterville, Messalonskee River	204.	204.	13.	6.32	.....	Including small allowance for buildings.
Massachusetts—						
Charles River, 5 mills	....	...	26.7	....	$185.40	2 m.g.d.
Ayer, Nashua River	302.	118.3	8.	21.20	.....	
Braintree	..	..	....	....	.....	Special case.
Cambridge, Stony Brook	23.	23.	16.	(60.29)	.....	Including value for other uses of water.
Easthampton, Manhan River	60.5	13.	16.	105.70	.....	
Groton, Salmon Brook	29.	1.1	25.	89.70	.....	Including interest and collateral items.
Hopkinton, Whitehall Pond	....	....	....	....	.....	Special case.
Holyoke, Manhan River	27.5	13.	13.5	49.30	.....	
Kingston	19.8	4.4	8.	(483.00)	.....	Special case.
Middleboro, Nemasket River	59.	48.1	10.	12.70	.....	
Northampton, Mill River	13.	7.2	30.	27.60	.....	
Northampton, Mill River	47.	7.2	14.5	145.20	.....	
Northampton, West Brook	13.1	7.2	18.5	20.10	.....	
Northampton, West Brook	13.2	7.2	22.5	30.90	.....	
Pepperell, Nashua River	434.1	118.2	19.	49.70	.....	
Southampton, Manhan River	34.7	13.	9.	13.53	.....	
South Deerfield, Mill Pond	39.2	3.7	14.5	43.50	.....	
Springfield Jabish Brook	....	10.6	123.5	34.30	.....	5 mills.
Waltham and Watertown, Stony Brook	251.4	23.	12.1 4. 4.80 5.80	24.40	.....	4 privileges.
Waltham, Stony Brook	4.1	4.1	8.	51.35	.....	
Westfield, Little River	81.	6.4	8.	54.10	.....	
Westfield, Little River	76.	6.4	10.			
Westfield, Little River	80.	6.4	18.	95.60		
Worcester, Kettle Brook cases	4.8 to 472.5	3.856	Various.	137.22	.....	45 privileges. 69 mills.
New Hampshire—						
Manchester, Lake Massebic	66.	45.	46.	24.20	.....	
North Carolina—						
Durham	120(?)	...	11.	....	$364.00	1 m.g.d.
New York—						
Brunswick, Quackenkill River	81.	17.5	29.	47.25	.....	Partially developed.
Fort Plain, North Creek	81.	4.65	19.	57.20	.....	4 owners.
Franklin	....	...	....	....	.....	Special case.
Little Falls	....	...	....	....	.....	Special case. Data incomplete.
Pittstown, Tomhannock Creek	1.8	1.8	20.	(91.40)	.....	Including some land and houses.
Pittstown, Tomhannock Creek	10.	10.	24.	(70.80)	.....	Including land and houses.
Rochester, Hemlock and Canadice Lakes	202.3	62.4	283.5	....	43.50 11.90	22 owners. First diversion, 9 m.g.d. Second diversion, 20 m.g.d.
Schagticoke, Tomhannock Creek	69.	67.	18.	9.95	.....	
Pennsylvania—						
Media	33.	29.9	25.	10.10	173.00	Partially developed, 1.5 m.g.d.
Crum Lynn, Crum Creek	34.9	29.5	13.5	8.50	180.00	
Springfield, Crum Creek	31.9	29.5	10.	33.90	500.00	2 m.g.d.
Vermont—						
Barre	42.	2.7	8.0	13.90	.....	
Barre	42.	2.7	12.3	40.80	.....	
Barre	42.	2.7	14.7	27.70	.....	
Barre	42.	2.7	22.6	18.00	.....	

Total, excluding figures in parentheses and giving multiplied weight to average figures for several privileges (each owned, perhaps by several mills) $9,119.24

Average (of 112 "Developed Privileges, by Award") $81.42

SUMMARY OF DEVELOPED PRIVILEGES—BY AGREEMENT.

Connecticut—						
Cheshire, Ten Mile River	73.5	1.6	6.9	54.40	.....	
Cheshire, Ten Mile River	7.3	1.6	9.8	63.80	.....	
East Lyme, Great Brook	16.5	6.4	9.8	23.90	.....	
East Lyme, Great Brook	16.4	6.4	11.7	52.90	.....	
East Lyme, Great Brook	10.4	6.4	20.	46.60	.....	
Meriden and Wallingford, 6 privileges on Quinipiac River	92.1 94.4 96. 100.4 106.4 106.5	1.6 1.6 1.6 1.6 1.6 1.6	18. 8. 7.1 5.9 8. 6.25	52.90	.....	6 privileges.
Montville, Great Brook	6.4	6.4	10.	(108.60)	.....	Includes mill.
Norwich, Yantic River	93.	1.5	71.	47.60	.....	
Norwich, Hammer Brook	2.5	1.5	Unknown.	....	.....	Special case.
Norwich, Ice Pond	0.6	0.3	5.	....	.....	Special case.
Plainfield, Mill Brook	20.	0.9	47.	37.80	.....	
Southington, Ten Mile River	16.6	1.6	5.7	54.80	.....	
Thompson, French River	94.	94.	1.5	53.20	.....	
Wallingford, Quinipiac River	110.5	1.6	6.9	181.20	.....	
Waterbury, Naugatuck River	21.	18.	12.	13.90	.....	
Waterford, Beaver Dam Brook	8.8	0.6	33.	147.00	.....	
Waterford, Beaver Dam Brook	8.8	0.6	20.	48.40	.....	

passed by this association, "the practicability of joint action with the National Cotton Manufacturers' Association, or other organizations of mill owners, relating to the formulation of standard rules of computing or assessing damages for the diversion of water," and has conferred with officials of various associations, and regrets that it must now report the impracticability of such action. The questions involved are so much a matter of law, the outgrowth of centuries of experience, and the nature of the problems to be passed upon is so diverse, and the interests involved are so many and even so antagonistic as to make it absolutely hopeless to attempt to formulate, or even to outline, any standard rules as suggested.

[A bibliography based on a search of the libraries of the American Society of Civil Engineers and the American Society of Mechanical Engineers, supplemented by other references, will appear with the full report when published in the Journal of the New England Water Works Association. Also, it is expected, a discussion of some of the legal phases of water-power awards, by Mr. Chas. F. Choate, Jr., and other lawyers, together with discussion by members of the association.—Ed.]

TABLE III.—RESULTING AVAILABLE NET TWENTY-FOUR-HOUR HORSEPOWER PER SQUARE MILE PER FOOT FALL UPON BASIS OF THE YIELDS OF THE FOLLOWING RIVERS:

Month.	23 years, 1875-1897.	Sudbury, 12 years, 1897-1908.	34 years, 1875-1908.	Nashua, 12 years, 1897-1908.	Croton, 32 years, 1868-1899.
Driest	0.0164	0.0083	0.0136	0.0328	0.0221
Second driest	0.0231	0.0197	0.0218	0.0474	0.0349
Third "	0.0369	0.0367	0.0357	0.0614	0.0468
Fourth "	0.0495	0.0523	0.0489	0.0768	0.0640
Fifth "	0.0656	0.0621	0.0630	0.0870	0.0792
Sixth "	0.0892	0.0741	0.0830	0.1006	0.1021
Seventh "	0.1108	0.0892	0.1030	0.1193	0.1200
Eighth "	0.1108	0.0892	0.1030	0.1193	0.1200
Ninth "	0.1108	0.0892	0.1030	0.1193	0.1200
Tenth "	0.1108	0.0892	0.1030	0.1193	0.1200
Eleventh "	0.1108	0.0852	0.1030	0.1193	0.1200
Wettest	0.1108	0.0892	0.1030	0.1193	0.1200
Average	0.0788	0.0657	0.0735	0.0935	0.0891
Average minimum.	0.0164	0.0083	0.0136	0.0328	0.0221

TABLE IV.—SUMMARY OF DEVELOPED PRIVILEGES—BY AGREEMENT. (Continued.)

Location.	Watershed, sq. mi. Total.	Watershed, sq. mi. Diverted.	Available fall, ft.	Award (excluding interest, etc.) Per sq. mi. of watershed per ft. of fall.	Award (excluding interest, etc.) Per million gals. daily ft. of fall	Remarks.
Massachusetts—						
Andover, Merrimac River	....	2.7	30.	14.80	.....	
Billerica, Merrimac River	352.	75.2	11.	87.50	.....	
Clinton, Wachusett Reservoir	113.4	113.4	15.5	35.20	.....	
Clinton, Wachusett Reservoir	118.3	118.3	28.	87.30	.....	
Framingham, Sudbury River	100.0	75.2	26.	67.20	.....	
Groton	118.3	428.5	8.	37.00	.....	
Lancaster and Clinton, Nashua River	128.8	118.2	8.	37.00	.....	
Lawrence, Merrimac River	4,599.	118.2	32.5	22.62	.....	Essex Company
Lawrence, Merrimac River	4,599.	75.2	32.	14.50	.....	
Lowell, Concord River	370.	75.2	24.8	70.90	.....	8 privileges.
Lowell, Concord River	375.	75.2	8.	28.80	.....	
Lowell, Concord River	380.	75.2	11.3	41.10	.....	
Lowell, Merrimac River	4,085.	118.2	39.	25.15	.....	Locks and Canals Company.
New Bedford, Assawompsett Pond	64.	12.8	13.5	27.80	.....	
Oakdale, Nashua River	94.8	94.8	27.	35.15	.....	
Oakdale, Quinepoxet River	53.8	53.8	22.8	24.30	.....	
Oakdale, Quinepoxet River	54.2	54.2	16.8		.....	
Springfield, Chicopee River	*	8.1	33.	21.10	.....	
Springfield, Chicopee River	*	8.1	28.	19.60	.....	
Springfield, Chicopee River	*	8.1	33.	7.20	.....	
Springfield, Chicopee River	*	8.1	43.	2.80	.....	
Springfield, Chicopee River	*	8.1	13.5	17.30	.....	
Wellesley, Charles River	....	...	...	92.40	.....	
West Boylston, Nashua River	98.3	98.3	11.	20.70	.....	
West Boylston, Nashua River	98.3	98.3	11.	20.70	.....	
West Boylston, Nashua River	98.9	98.9	18.4	29.10	.....	
Maryland—						
Baltimore, Yantic River	280.	....	10.	.....	$100.00	Up to 150 m.g.d.
New Hampshire—						
Ashland, Winnepesaukee Lake, 2 mills	56.7	56.7	29.	($6.08)	.....	Including buildings. In 1888.
Bristol, Winnepesaukee Lake	91.	91.	46. (?)	($3.58)	.....	In 1884.
Nashua, Nashua River	522.0	118.2	35.3	33.60	.....	
	406.1	118.2	11.0		.....	3 privileges.
	527.3	118.2	22.3	58.00	.....	
Tilton, Laconia and Guilford, on Lake Winnepesaukee	366.	366.	16.	6.75	.....	In 1889.
	428.	428.	12.		.....	
Wolfboro	24.	24.	18.	13.87	.....	In 1889.
New York—						
Brunswick, Quackenkill River	25.3	17.5	3.	52.38	.....	
Troy, Poestenkill Creek	96.	17.5	12.	23.80	.....	
Pennsylvania—						
Bradford	104.	14.	9.5	(112.80)	.....	Including mill. 1.5 m.g.d.
Springfield, Crum Creek	25.	25.	10.	20.00	.....	
Rhode Island—						
Woonsocket, Blackstone River	472.	7.9	174.9	137.00	.....	Average, 6 privileges.

Total, exclusive of amounts shown in parenthesis, *giving multiplied weight to average records* for several privileges, each owned, perhaps, by several mills..... $3,623.42
Average (of 66 "Developed Privileges by Agreement" 54.90
Average of 178 "Developed Privileges by Award and by Agreement"..... $71.55

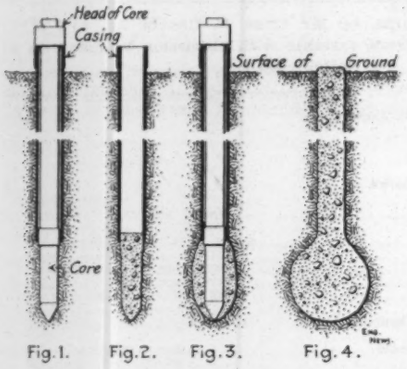
SUMMARY OF UNDEVELOPED, ABANDONED, OR UNUSED PRIVILEGES—BY AWARD.

Connecticut—						
Putnam, Little River	40.8	....	33.	.....	$136.00	500,000 g.p.d.
Massachusetts—						
Waltham, Stony Brook	21.5	21.5	29.6	$15.72	.....	Practically an abandoned privilege.
Westfield, Little River	21.	6.4	10.	6.98	.....	
New Hampshire—						
Nashua, Nashua River	528.	118.2	....	.....	.....	Special damage.
New York—						
Ithaca, Taughannock River	67.	67.	543.	2.21	.....	
Rome, Fish Creek	135.	...	273.	0.25	.....	
Schaghticoke, Tomhannock Creek	69.	67.	18.	3.73	.....	
Schaghticoke, Tomhannock Creek	75.	67.	150.	2.19	.....	Unused privilege.
Schaghticoke, Tomhannock Creek	78.	67.	40.	5.97	.....	
Schaghticoke, Tomhannock Creek	80.	67.	8.	2.24	.....	
Pennsylvania—						
Springfield, Crum Creek	33.7	21.9	11.	11.20	123.00	Abandoned privilege.
Vermont—						
Barre	42.	2.7	28.3	11.80		
Average (of 10 "Undeveloped Privileges by Award")				$8.22		
Connecticut—						
Cheshire, Ten Mile River	6.3	1.6	16.	5.86	.....	
East Lyme, Great Brook	16.4	6.4	9.5	19.60	.....	
East Lyme, Great Brook	16.4	6.4	9.1	25.60	.....	
East Lyme, Great Brook	14.2	6.4	11.	8.60	.....	
Maine—						
Tributary to Kennebec	200.	200.	38.	1.71	.....	
Tributary to Kennebec	200.	200.	48.	2.50	.....	
New Hampshire	3,000.	...	20.	4.70	.....	
New York—						
Brunswick, Quackenkill River	91.3	17.5	55.1	6.23	.....	
Brunswick, Quackenkill River	91.3	17.5	10.6	5.40	.....	
Brunswick, Quackenkill River	18.1	17.5	74.	1.04	.....	
Pennsylvania—						
Springfield, Crum Creek	33.7	29.5	14.	8.48	$125.00	Abandoned privilege.
Average (of 11 "Undeveloped Privileges by Agreement")				$8.15		
Average (of 21 "Undeveloped Privileges by Award and by Agreement")				$7.23		

Concrete Piles with Enlarged Bases.

By HUNLEY ABBOTT.*

It has been recognized that a great deal of additional strength and stability may be gained by having an enlarged foot or base at the lower end of a pile. More than a hundred years ago the screw and disk piles were in use in England and in this country. In recent years several cast piles have been made with enlarged feet and the "belling out" of caissons at their lower end is an example of the same thing on a somewhat larger scale. In Boston a few years ago some



Figs. 1-4. Successive Operations in the Formation of the Pile.

concrete piles were made by chambering out a cavity at the lower end of the pile with a toggled cutting tool.

Hitherto, although it has been universally recognized that an enlarged foot was a most desirable thing, the trouble has been to get the foot down. The screw pile necessitates a very slow and laborious method of placing, the disk pile can be used in only one class of soil and the difficulties of chambering out a cavity 20 to 50 ft. under ground through a small pipe are obvious.

A method for making and driving such a pile in a strong and simple manner has recently been devised. The apparatus necessary to form this pile consists of a "casing" and a "core." The casing is a 16-in. steel pipe ⅜-in. thick, and the core is a smaller and longer pipe with a cast steel point and an enlarged cast steel head. The core fits inside the casing, its enlarged head engages the top of the casing and its lower end projects some 4 ft. below the lower end of the casing. In the head of the core is an oak driving block which receives the blows of the hammer. To drive, the core is fitted into the casing and the two driven into the ground to the desired depth (Fig. 1). Then the core is pulled out and a charge of concrete dropped down to the bottom of the casing (Fig. 2). The core, or rammer as it now becomes, is lowered into the casing and driven down through this charge of concrete, pushing it to either side as shown in Fig. 3. This operation of placing charges of concrete and of ramming is continued until a large bulb or foot of the desired size is formed (Fig. 4). If the soil just below the foot is somewhat harder than the soil above, the foot will flatten out on the bottom to some extent.

After this foot has been formed, the casing is filled to the top with concrete and then pulled out of the ground leaving a 16-in. diam. concrete column resting on a spread base or pedestal. This column can be easily reinforced with steel rods if greater strength is desired in that part of the pile.

It is evident that this pile will carry a considerably greater load under given conditions than a straight pile without the foot. It has all the frictional area along the stem that the straight pile has and also some around the horizontal circumference of the foot. In addition to this friction, it has the bearing value of the projected area of the foot on the firm soil at the lower end of the pile. This soil has been compressed and compacted by the ramming of the concrete during the formation of the foot and is therefore capable of bearing a greater load than it was before the driving of the pile. Experiments have been made with this pile in a number of different kinds of soil and it has been found that the shape taken by the foot is in all cases roughly spherical, as shown in Figs. 4 and 5.

Some loading tests in the yards of the Lackawanna Steel Co. at Buffalo showed that in the soft muck along the lake front the bearing power of a concrete pile with enlarged foot was two and one-half times that of a pile of the same length without the foot.

During the installation of concrete piles for the foundations of the new U. S. Post Office building at St. Louis, some tests of this new method were made and showed very satisfactory results. These tests were made through the courtesy of the government and the contractors for the pile-driving. Concrete piles 35 ft. long were called for on this work and the specifications required a test load of 40 tons to be carried for 24 hours with a settlement of less than ½-in. The test piles driven according to this new method were only 24 ft. long, but they carried the specified test load of 40 tons for 24 hours and with a settlement considerably less than what was allowed. These piles penetrated about 18 ft. of old cinder and trash fill and 6 ft. of soft yellow clay of the consistency of putty. One of these piles was dug up and a photograph of it is shown in Fig. 5. The shaft of this pile is 16 ins. in diameter and the foot measures 4 ft. 3 ins. on its horizontal diameter.

Two hundred and eleven of these piles have just been driven for the foundations of the new post office building at Paris, Ill. These piles averaged 19 ft. in length (measured from top of head to bottom of foot) and penetrated through a stratum of from 2 to 3 ft. of quick sand. This work at Paris was finished within the promised

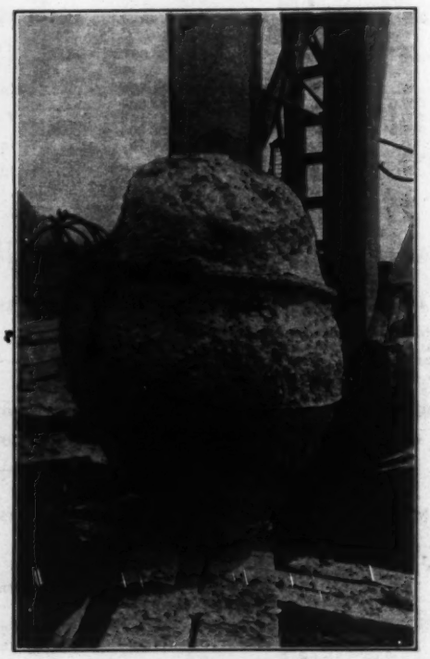


Fig. 5. Near View of Enlarged Base on Test Pile.

time and was executed to the complete satisfaction of the contractor and the government.

The system described herein is controlled and operated by the U. S. Equipment Co., Fisher Bldg., Chicago.

*11 Pine St., New York City.

PANAMA CANAL EXCAVATION during November, 1909, totaled 2,458,152 cu. yds., a daily average of 102,423 cu. yds. for the 24 working days. During the month 41,368 cu. yds. of concrete was laid and 285,777 cu. yds. of fill placed. The work during the month was hindered by the excessive rainfall which reached 28.50 ins. for the 30 days. This is very nearly the highest monthly rainfall observed on the Isthmus.

A Brief Water Shortage at Springfield, Mass., Caused by Ice Crystals in the Gate Chamber of the Ludlow Reservoir.

By ELBERT E. LOCHRIDGE,* Assoc. M. Am. Soc. C. E.

Minute ice crystals in the gate chamber of the Ludlow reservoir caused a water shortage in Springfield, Mass., for a few hours on Dec. 1. The attendant circumstances, including those pertaining to the interruption and restoration of full water service, were interesting.

The Ludlow reservoir from which the city at present takes its supply was divided a number of years ago by means of a dike into the main reservoir with an area of 440 acres and a basin with an area of about 10 acres. This division was to enable the by-passing of the reservoir by means of a canal and the use of brook water direct at times when the reservoir water was unusable on account of growths of algae. Later, with the construction of the intermittent filter, primarily designed for the removal of these organisms, the suction for this filter was placed in the main reservoir and the effluent from the filter was delivered to this small basin. At the time of the construction of this dike it was not contemplated that the present demands of water consumption of Springfield would be so large. The entire amount must now of necessity pass through a 36-in. pipe and supply the basin, which in turn delivers water to the gate-house, supplying the main pipes to the city. As this basin had a depth of but about 10 ft., a canal of an additional 10 ft. depth was cut through the basin to deliver water from the lower depths of the reservoir. At the present time, this canal contains all the water that supplies the city. The loss of head in delivering water from Ludlow reservoir at its present low stage under the dike and through this canal resulted in lower water at the gate-house than in the main reservoir, this varying sometimes up to a range of 2 or 3 ft.

On the night of Nov. 30, the writer was at this gate-house until after dark looking into methods of getting water to the city more freely. At this time, there was no ice whatever on the reservoir or in the basin.

At a few minutes before six o'clock the following morning the pressure at the gage in the water office dropped rapidly from 120 to about 50 lbs. On being notified of the loss of pressure, the writer reached the reservoir, twelve miles from the city, about eight o'clock and found the space back of the ¼-in.-mesh screens used for keeping the pipes free from leaves, fish, etc., entirely filled with a mass of minute ice crystals, very thin and fine but present in immense amounts. Work of about forty-five minutes started this mass moving and the full amount of water was returned to the pipes to the city just three hours after the accident occurred. On this morning the reservoir was covered with ice firm enough to hold a man, showing the severe drop of temperature during the night and showing how this ice could have been formed in the canal, and when the morning use came on how it was quickly swept into the gate chamber, forming a large mass of these small ice crystals and entirely stopping the supply.

The city is composed of two sections, the business section lying at a lower level and the hill section including the larger portion of the residences and some manufacturing on a plateau which is 125 ft. higher. Both of these sections have the same service and in the lower portion of the city the pressure never dropped below from 45 to 50 lbs., pressure being entirely absent in the hill section. No pressure was recorded for the hill section until late into the night of Dec. 1, and no satisfactory pressure was available in this section until the night of Dec. 2. This was due to the use of water by the city and the presence of air in the pipes. The pipes were not ample to supply the deficiency and also the regular and emergency uses demanded by the hill section as soon as water was restored.

*Chief Engineer, Water Department, Springfield, Mass.

A large number of men were placed promptly on hydrants and air valves so that every possible means of removing the air was taken at once, but it was not until 1 a. m., Dec. 3, that it was possible to open the air valves on the pipe lines passing through the country, as up to this time air was drawn into these pipes on account of the high velocity of the water passing through them, instead of being excluded; thus making it necessary to remove the air from the lower portions first, slowly forcing it back out from the pockets on the higher portions of the line.

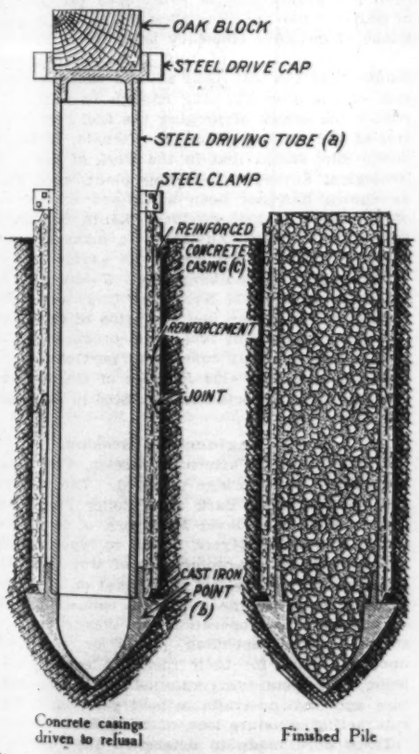
No fire occurred during the time when the pressure was lacking. This was as fortunate as it was remarkable when the population and number of risks are considered.

Incidentally, the cement-lined main which has been in service for thirty-five years was apparently in no way damaged by the sudden removal of water from it and the refilling and forcing of the air from it.

The stoppage and its attendant circumstances does not appear to have permanently affected any part of the water service.

A Concrete Pile with Concrete Shell and Removable Steel Core.

Another concrete pile has been put on the market. It has a number of variations, but the general type is shown in the accompanying drawing. As will be noted there, the main features of the pile are a cast-iron point, a hollow steel driving tube and a sectional reinforced-concrete outer shell. The point, tube and shell are all driven, adding the sections of shell as the pile descends, and when a proper depth has been reached the inner tube is withdrawn. The



Standard Design For the "Peerless" Concrete Pile.

shell can then be inspected for alinement and condition, and if satisfactory, filled solid with concrete. For this concrete filling there has been devised a special tremie, with a bottom dumping gate and side filling doors at different elevations. It is intended that the shells be made in special forms on the site of the work and allowed a sufficient time to set before being used.

The system is patented under the name of "Peerless" concrete piles, by the American Concrete Piling Co., Philadelphia, Pa.

The Board of Water Supply Dinner, New York City.

That a water-supply system of unprecedented magnitude is being built for New York City is quite generally known, but relatively few people are aware of the great size, high character and rare esprit des corps of the engineering organization that is now engaged in carrying on the work. All these qualities of the corps were made apparent at a dinner given to the commissioners and staff of the Board of Water Supply, on Dec. 10, by Messrs. J. Waldo Smith and Chas. L. Harrison, Ms. Am. Soc. C. E., Chief and Deputy Chief Engineer of the Board. Staff and guests together numbered seven hundred or more.

In opening the after-dinner speeches, Mr. Smith stated that a large percentage of the work comprised in the new Catskill supply is already under contract, including the Ashokan Reservoir and a considerable part of the ninety-mile Catskill Aqueduct. The two watchwords have been and are honesty and speed. Mr. Smith made a strong heart-to-heart appeal to the members of his staff for continued devotion to their work.

The Hon. Geo. B. McClellan, Mayor of New York City, having been introduced as the representative of the city government who terminated the long period of inaction as to an additional supply, made an admirable speech, which was received with marked approval.

Among the other speakers of the evening were ex-Gov. B. B. Odell, Mr. A. C. Humphreys, M. Am. Soc. M. E., President of Stevens Institute, and Mr. John A Bensel, M. Am. Soc. C. E., Chairman of the Board of Water Supply.

Two lively features of the dinner were oft-repeated cries, like college yells, from groups of engineers, associated with various divisions of the work, and the singing of songs from a sizable pamphlet placed at the plate of each diner, entitled "Board of Water Supply Songs." These effusions, set to various popular tunes, ran up well toward fifty in number. The songs dealt with the work in hand and the men at its head and many of them were sung with great spirit. We give the following as samples:

THE MAYOR.

(1) Shall our young Mayor be forgot,
Who put our project through,
Who knew the unwashed city's need,
And gave us work to do?

CHORUS.

Oh, may his shadow ne'er be less;
And may his income grow!
He'll always be remembered where
Esopus' waters go.

(2) There'll be much drink, there'll be much wash,
For New York's families;
So take a cup and drink it up
To the health of Georgie B.

WORKING FOR WALDO.

(1) Bring the good, old transit, boys;
We'll rush the job along,
Run the rods around the hills,
Get at it good and strong;
Plot the stuff and send it in,
Be sure there's nothing wrong,
While we're working for Waldo.

CHORUS.

Hurrah, hurrah, we'll rush the job along!
Hurrah, hurrah, for McClellan we are strong!
Work like hell, with all your might;
For the Board we'll shout a song,
While we're working for Waldo.

(2) Down along the aqueduct,
They're working day and night—
Running lines to put a conduit,
Way down out of sight;
All along the Hudson
Boring down with all their might
While they are working for Waldo.

(3) In the New York office
Flinn is working with a vim,
Changing every blessed thing
That we send down to him,
Planning dams and aqueducts,
And tunnels, dark and dim,
While he is working for Waldo.

(4) On Long Island's sunny hills
The Board has sent a force
To prospect down among the sands
For some subaqueous course;
So Baby town can have a drink
Without the Catskill's source,
While they are working for Waldo.

(5) Up here, in the Reservoir,
Our topo' maps are done;
The work upon the real estate
Is going with a hum;
The Railroad line is in the air,
Some highway work begun,
Here we are working for Waldo.

WATER POWER.
(Visionary.)

(1) Oh! Mirandy, have yer heard about the water power claims
That they're puttin' in at Kingston under everybody's names?
Now, we've got ter put in ours, so the lawyer fellers say,
That is what them experts said to me in Kingston court to-day.

CHORUS.

Now is the time, Zeke, Esopus Creek,
The spring by the hill, or the rain barrel leak;
Or even that ditch that runs by the barn—
We have got ter find a water power claim upon the farm.

(2) We have got ter get an engineer to guess about the flow,
And measure up the head and then to add a foot or so;
Then to come to court and swear for us as how we had in mind
For to start to light up Albany, or some place of the kind.

(3) O, I reckon when McKenzie swears he'd build the factory,
Down behind the wagon shed along beside the apple tree,
And when Burhans figgers out the flow as by rule of three,
There will be a fortune in the thing, my dear, for you and me.

(4) We will buy a house in Kingston, or we may get two or three,
And we'll almost every evening go to hear the operee—
But the only thing thet bothers me—I think it is a shame—
Is the poor folks round here as ain't got no water power claim.

Those acquainted with New York politics will appreciate the following question song, addressed to the mayor-elect, who will assume office on Jan. 1, 1910:

OH, JUDGE GAYNOR!

For it's oh, Judge Gaynor! how are you?
Is there anything we can do for you?
Just name it if you can; we are with you to a man,
For it's oh, Judge Gaynor! how are you?

Annual Meeting of the American Society of Mechanical Engineers.

The 30th annual meeting of this society was held in the Engineering Societies Building, New York City, last week. The opening session on Tuesday evening was chiefly a social affair. The retiring President, Mr. Jesse M. Smith, delivered the annual address, taking as his subject "The Engineering Profession." An abstract was given in our last issue. The election of the new officers was announced, and the result of the letter ballot declared as follows:

Mr. George Westinghouse was elected President. The three new Vice-Presidents are Messrs. Charles Whiting Baker, of New York City; W. F. M. Goss, of Champaign, Ill.; and E. D. Meier, of New York City. The three new Managers are Messrs. J. Sellers Bancroft, of Philadelphia; James Hartness, of Springfield, Vt.; and H. G. Reist, of Schenectady, N. Y.

Announcement was made that the spring meeting of the society will be held as usual, notwithstanding the joint session which has been arranged with the Institution of Mechanical Engineers of Great Britain in July. The date of the spring meeting will be May 31 to June 3, and it will be held in Atlantic City.

The society has received a gift of a bronze replica of the memorial of the late Prof. Robert H. Thurston at Cornell University. The formal dedication of this memorial is to take place at the February meeting of the society.

The session on Wednesday morning was devoted to the annual reports of the Council and various standing and special committees of the society. At various times the society has done important work in standardizing the methods of testing boilers, engines and other power machinery. Some of these old standards need revision, and new standards are desirable for the testing of newer forms of power apparatus. A committee has therefore been created on power tests, which is to revise the old standard codes and extend them so as to apply to gas-power machinery, water-power plants, etc. The chairman of this committee is Dr. D. S. Jacobus. Dr. Jacobus made for his committee a report of progress. He stated that the present plan of the committee is to make a single report on a standard power test, the first part of which will deal with such tests in general, calibration of the apparatus, etc., and the second part of which will be subdivided to apply to the various classes of

machines and apparatus. A preliminary draft of such a standard code has been made by Mr. George H. Barrus, and the committee is proceeding to discuss and amend this preliminary draft and will later distribute copies with a request for general criticism.

Certain amendments to the constitution of the society, offered at the Washington meeting, were adopted and ordered to letter ballot without dissent. These amendments define more clearly the grades of associate and junior in the society, and add to the list of standing committees of the society a committee on public relations, which has to do with the lines in which the society may usefully use its influence in public matters.

The discussion during the morning session centered chiefly on details of the proposed standard power test on which Prof. Jacobus's committee is at work.

No session was held during Wednesday afternoon, but the time was devoted to visiting the vast new terminal station of the Pennsylvania R. R. at 32d St. and Seventh Ave. This station, probably the largest and most expensive railway passenger station ever constructed, is in a stage where the operation of placing the final tracks, machinery, etc., can be readily inspected. The party of visitors was escorted through the station by Mr. George Gibbs, M. Am. Soc. C. E., Chief Engineer of the Pennsylvania Tunnel & Terminal R. R. Co., and a number of his engineering associates. This was the only excursion participated in by the members as a whole. A considerable number of other excursions to manufacturing plants, power-houses, etc., in New York City and vicinity, were arranged by the local reception committee and were largely attended by the visiting members. The principal social event of the meeting was the reception, which was held on Thursday evening at the Hotel Astor. On Wednesday evening an illustrated lecture on the development of agricultural machinery was delivered by Mr. L. W. Ellis, of the Department of Agriculture.

Several of the papers presented in the professional session of Thursday and Friday have already appeared in Engineering News. A report of these professional sessions follows.

Measurement of the Flow of Fluids.

One of the professional sessions was given up to papers and discussions on measurements of the flow of fluids—water, steam and gas.

The first of these papers was "Tests of a Venturi Meter for Boiler Feed," by Prof. C. M. Allen, of Worcester, Mass. In making the tests described it was attempted to reproduce actual boiler-room conditions as far as possible. Several pumps in good and in poor condition were used to introduce both steady and varying intermittent pressures as desired. The Venturi meter was an ordinary 2-in. size and the readings were taken on a mercury manometer tube. Water, at temperatures of 80°, 120°, 140° and 180° F., was used and it was found that the correction factor (by which the discharge computed from the meter readings needed to be multiplied) varied from 0.935 at 40° F. to 0.962 at 200° F. For steady flows the average errors were within 1%, and with pulsations due to the pumps the maximum error was about 2.5%. With injectors causing the flow the average error, due to variations of temperature with velocity, was within 2%.

The particular size of meter did not prove satisfactory for velocities of less than 10 ft. per sec. For cases where such velocities prevail a smaller meter was recommended.

In "The Pitot Tube as a Steam Meter," Prof. G. F. Gebhardt, of the Armour Institute of Technology, Chicago, described several forms of a type of steam meter in which a very small amount of steam was shunted through the instrument from the main in which the velocity of flow was to be found. All the instruments described were laboratory devices which, on account of the many chances for variation, were not commercial instruments. In all of these devices a column of condensed steam balanced the difference of pressure between the two nozzles of the Pitot tube—the "dynamic nozzle" pointed against the steam flow and the "static nozzle" receiving only the normal pressure of the steam line. The first instrument shown was a simple arrangement of a gage glass between the two nozzles. In this, excess condensation drained off into the main through the dynamic nozzle so that there was a constant initial column of water in the glass. The second design was similar, but combined both the Pitot nozzles in one pipe connection. The third device had a separate overflow for the condensed steam so that the dynamic nozzle was not filled with water. The fourth instrument had a system of float, levers, gears and pivoted magnet, inside a pressure case, with a dial, pointer and pivoted magnet outside the pressure case. Changes in velocity of steam flow caused a movement of the float. This movement was transmitted to the magnet, which gave a corresponding motion to the outside magnet and pointer. In the fifth instrument a small jet of steam, from the dynamic nozzle, impinged on the periphery of an aluminum wheel. Revolution of the wheel was resisted by a spiral spring and such motion as was given the wheel was transmitted to the pointer through magnetic gearing quite like that in the fourth device.

In the paper, "Efficiency Tests of Steam-Turbine Nozzles," prepared by Prof. F. H. Sibley, of University, Ala., and Mr. T. S. Kemble, of Cleveland, Ohio, description was given of a novel and satisfactory method of determining the reaction of steam turbine nozzles. The nozzle was suspended, in a vacuum box, at the end of a long flexible steel tube. The deflection of the long tube by the reaction of the nozzle was measured by the distortion of a calibrated spring. This spring was calibrated, in place, by deflecting the tube with weights in order to eliminate friction. The paper presents complete summaries of the studies made and data derived. It was found (1) that the efficiency of a nozzle could be determined with an error of 2% or within, (2) that some nozzles showed an efficiency (ratio of kinetic energy to available heat energy per unit mass) of 88-92%, and others as high as 98%, but the efficiency was found affected more by smoothness of inside finish than by contour, (3) that the reaction is decreased if the pressure of the surrounding medium is greater than the steam pressure in the plane of the nozzle muzzle and vice versa.

"An Electric Gas Meter" was presented by Prof. C. C. Thomas, of Madison, Wis. The operation of the meter depended on the ideas of adding a measured amount of heat to gas flowing through a pipe and of measuring the rise in temperature to determine the quantity flowing. An electric heater is designed to obstruct the flow of gas in such a way as to impart heat uniformly and at a regular rate. The amount of heat imparted is known from the electrical energy furnished to the heater. The temperature of the gas after passing through the heater is measured by electrical thermometers, consisting of parallel wire coils arranged across the whole cross-section of the gas way. In the form designed for commercial operation a fixed elevation of the temperature of the incoming gas is automatically maintained and the varying electrical energy required to do this is registered on a recording wattmeter in terms of the flow of gas. The energy ordinarily used has been found to be about 1 KW. per 50,000 cu. ft. per hr. The author claimed that, while the meters needed calibration for exact and absolute measurements, yet the quantity flowing could be calculated, with but slight error, from the energy input and from the specific heat of the gas flowing.

In the discussion of this paper, Prof. L. S. Marks, of Cambridge, Mass., held that, with gas carrying fine spray, there was chance for an error of 20 to 25%, arising from a change of the saturation point of the gas for the changed temperature. He held that one machine could not be generally calibrated on one gas and used on another as the product of different gas companies varied as much as 10% in specific heat. Error was introduced also as the product of any one company varied as much as 2% in specific heat from time to time.

Gas-Power Section.

At the single session of this section a little routine business was transacted and two papers were presented. In addition two of the committee reports presented were equivalent to formal papers. As the result of letter ballots reported, Mr. J. R. Bibbins, of New York City, was declared elected chairman of the Gas-Power Section.

The report of the Plant Operations Committee included a standard set of forms to be used in connection with the operation of gas-power plants to show (1) load curve for various times of the year, (2) cost, character and amount of operating materials, (3) character and cost of labor, (4) repairs, (5) detail dimensions, (6) reliability of operation. Six forms were shown: (1) producer log, (2) engine log, (3) load-curve sheet, (4) monthly-data sheet, (5) monthly-cost sheet, (6) dimension sheet.

This report, with the forms suggested, was accepted. It is expected that the forms, to be widely recommended, will form the nucleus of a code which shall hold a position similar to that of the society's code for boiler trials.

The paper, "Testing Suction Gas Producers with a Koerting Ejector," by Messrs. C. M. Garland and A. P. Kratz, of Urbana, Ill., was read by Dean W. F. M. Goss. The tests shown in the paper were made to develop a producer trial that did not require the use of a gas engine for any loading—a trial similar to "blow-off" boiler tests. The engine was replaced by a steam ejector and the gas after passing through meters was discharged into the atmosphere. It was necessary to remove the steam, thrown into the gas at the ejector, with a scrubber-condenser and a dryer. The full details of the test were included in the paper. The only remarkable features were the very large amounts of dry coal fired per square foot of great area (an average of 38.8 lbs. per hr. being shown) and the maintenance of ordinary efficiency under such forcing.

In the discussion of this paper, several contended that the test itself showed that the duration of run was not long enough to sufficiently reduce the errors of judging the fuel bed at the end of the run. Prof. R. H. Fernald, of Cleveland, Ohio, stated that in the work of the U. S. Geological Survey fuel-testing plant, such tests as shown had not been attempted on account of prejudice against producer plants, so that it had always seemed advisable to make all tests complete, utilizing the gas in an engine.

The paper, "Bituminous Gas Producers," by Mr. J. R. Bibbins, of New York City, was a discussion of the design and operation of the Westinghouse bituminous-fuel, gas producer. This paper is very largely covered by part of a report of a committee on Gas Engines of the National Electric Light Association, reprinted in Engineering News, July 1.

Steam Engineering Session.

At the Thursday afternoon session, Vice-President L. P. Breckenridge presided. The first paper, entitled "Tan Bark as a Boiler Fuel," was presented by Mr. David M. Myers, of New York City. It was Mr. Myers' object to report in this paper the chief characteristics of wet spent tan as a fuel for boilers. It was based on a number of tests made by the author in connection with the remodeling, operation or construction of steam plants, depending partly or principally upon tan bark for their fuel. In condition for firing, wet spent tan contained about 65% moisture and had an available heat per pound, after subtracting moisture loss, of 2,665 B.t.u.

Tests were made to determine the results of using presses to reduce the moisture in the tan before firing. Although these tests showed only a very small gain in thermal efficiency when the tan presses were used, the author was of the opinion that their use might have resulted in good economy if the grate surface had been properly reduced to meet the demands of the more rapid combustion. A refractory arch over the furnace and a generous combustion space were required for tan burning, and a somewhat higher draft is required than for the same boiler output with bituminous coal. The average boiler horsepower per square foot of grate surface was

2.08 with oak tan and 1.5 with hemlock tan. Higher values may be obtained by the admixture of coal. The highest thermal efficiency of boiler and furnace obtained (based on available heat in tan) was 71.1%.

Mr. Albert A. Cary, of New York City, presented a written discussion describing an improved form of charging tube for tan-bark furnaces and a modification of the furnace itself which tended to prevent the formation of holes through the fire at the sides of the grate. Mr. Cary had used cast-iron rolls of 12-in. and 14-in. diameter, with roughened faces for extracting moisture from spent tan and had obtained in this way more than double the extraction of the presses used by Mr. Myers.

The paper on "Cooling Towers for Steam and Gas Power Plants," by Mr. J. R. Bibbins, is published elsewhere in this issue. In the discussion of this paper, Mr. Geo. J. Foran, of New York City, brought it out that the advantages of a low difference of temperature in a condenser between entering steam and leaving water (see Fig. 7 of Mr. Bibbins' article) did not apply without reservation to surface condensers. A low temperature difference required much greater cooling surface, more cooling water and greater cooling-tower capacity. Some doubt was expressed as to the practicability of the induction type of forced draft suggested in Mr. Bibbins' paper.

In the absence of Mr. W. P. Caine, of Ensley, Ala., his paper on "Governing Rolling-Mill Engines" was read by Mr. Richard H. Rice, of West Lynn, Mass. This paper, after an introductory portion advocating the three-high rolling mill as opposed to the two-high mill, described the results obtained in the operation of a rolling-mill engine at the Ensley rail mill of the Tennessee Coal, Iron & R. R. Co., by the addition of a special adjusting screw to the governor mechanism. The secretary, Mr. Calvin W. Rice, read two written discussions of this paper contributed by Mr. Henry C. Ord, of Milwaukee, Wis., and Mr. James Tribe, of Milwaukee, Wis., both of whom defended the two-high mill.

Mr. F. W. Dean, of Boston, Mass., presented two papers entitled "An Experience with Leaky Vertical Fire-Tube Boilers" and "The Best Form of Longitudinal Joint for Boilers." The first of these describes two large vertical boilers, designed by the author for a paper mill at Cumberland Mills, Me., with which there was trouble from the start with leaks at the juncture of the tubes with the lower crown sheet. This trouble was finally entirely remedied by raising the boiler so as to increase the height of the lower tube sheet above the chain grate from 7 ft. to about 12 ft. After this change, the boiler, which was about 10 ft. in inside diameter and had 488 tubes (2½-in.), developed on test 1,005 boiler horsepower at an equivalent evaporation of 10.34 lbs. of water per pound of dry coal.

The author ascribed the difficulty at first experienced to the collection of deposits of slag on the lower tube sheet. The slag was carried up from the fire by the strong induced draft used. Col. E. D. Meier, of New York City, told of a somewhat similar difficulty with oil-burning water-tube boilers. In this case, slugs of oil would fly up and adhere to the tubes and carbonize, causing tubes to burn out. The trouble was remedied by deflecting the fuel jet downward toward the bottom of the combustion space.

Mr. Dean's second paper proposed, for the longitudinal seam of boilers, a butt-joint with the inside and outside straps of equal width to replace the more commonly used butt-joint with the inner strap wider and having one or more rows of rivets beyond each edge of the narrower strap. The author believed that the outer rivets formed an overhung connection possessing to some extent the recognized defect of the lap joint. It was pointed out by Col. E.D. Meier that the diameter of the shell would affect the desirability of the form of joint proposed by Mr. Dean. In the relatively smaller drums of water-tube boilers, in particular, the longer inside butt strap was of value in modifying the bending effect at the joint of changes in diameter due to expansion and contraction.

Friday Morning Session.

The opening paper of the Friday morning session was entitled "The Bucyrus Locomotive Pile Driver," by Mr. Walter Ferris, of South Milwaukee, Wis. This paper was published in Engineering News, Nov. 18, 1909. Two written discussions of the paper, contributed by Mr. A. F. Robinson, Bridge Engineer of the Atchison, Topeka & Santa Fe Ry., and Mr. L. J. Hotchkiss, Assistant Bridge Engineer of the Chicago, Burlington & Quincy R. R., were read by Mr. L. G. French, editor of the "Journal" of the society. These contributions discussed the advantages of the new pile driver and the results obtained with it in actual use.

In a paper on "Line-Shaft Efficiency, Mechanical and Economic," Mr. Henry Hess, of Philadelphia, Pa., gave the results of a comparative test of plain, ring-oiling, babbitted boxes and ball bearings for line-shaft hangers. The test was made on a 72-ft. length of 2 7-16-in. shaft used to operate a set of heavy turret lathes, and the entire shaft was equipped alternately with the two types of bearings to be compared. The saving due to ball bearings with medium load was found to be about 35% of the plain-bearing friction, or about 20% of the total power. This showed an annual saving of 37% of the extra investment required.

In answer to questions, Mr. Hess stated that the friction of ball bearings was, in general, less than that of roller bearings, owing to the loss due to slight deflections of the rollers. Roller bearings were desirable for some installations on account of their relative cheapness. Ball bearings had been tried on many railways, but these experiments were for the most part made long ago when modern materials and workmanship were not available. Ball bearings on a German railway recently had traveled in suburban and express service 400,000 kilometers without appreciable deterioration. The cost was much higher than for plain journals, but the thing to be considered was the return on the extra investment. In street railway work, in particular, the increased ability to coast resulted in large power savings. At the present time, the chief difficulty in introducing ball bearings into railway work was inertia—not of the rolling stock, but of the managers.

A paper on "Pump Valves and Valve Areas" was presented by Mr. A. F. Nagle, of South Bethlehem, Pa. Mr. Nagle contended that the customary specification that the area through the valves should exceed by some certain per cent. the area of the plunger was an incomplete requirement. It did not definitely attain its object, which was to reduce the power required to force the water through the valves. The strength of the valve springs was the thing that determined the power loss at the valves. If the springs were not made too strong, the valve area need not be larger than that of the plunger. In this way it was possible to reduce the size of the valve chambers as much as 10%, and, as these were the largest and weakest castings of a pumping engine, the reduction was well worth striving for.

Mr. Chas. A. Hague, of New York City, in a contributed discussion read by Mr. French, objected to the high lift of the valves that would result from weaker springs. Valve area should be designed to give an average velocity of not more than 3½ ft. per second through the valves. Mr. Nagle replied that the valve area alone did not determine the velocity. The springs in common use gave a pressure of from 0.3 to 0.6 lb. per sq. in. of valve area and this resulted in a lift so low that the velocity was 10 or 14 ft. per second.

Mr. Nagle presented also a paper entitled "A Report on Cast-Iron Test Bars." This report indicated that too much confidence should not be placed in test bars as indicative of the exact strength of castings. A discussion contributed by Mr. W. B. Gregory, of New Orleans, La., gave the results of tests made to determine the effect of rattling on the strength of castings. The breaking load of cast-iron test bars (1 in. square, 12 ins. between supports) was found to be increased from 2,805 lbs. to 3,474 lbs. by rattling. A mathematical discussion was contributed by Mr. Geo. M. Peek, of Pittsboro, N. C., in which a formula for the tensile strength of cast iron was derived. Mr. Albert A. Cary, of New York City, suggested that the variations in strength of test bars might be explained by micro-metallurgy.

A Drilling Auger for Prospecting for Coal Above Water Level.*

By BAIRD HALBERSTADT.†

Some few years ago, the writer was engaged to examine and report on a tract of land, comprising some 75,000 acres, in West Virginia. The primary object of the examination was to determine whether this tract in whole or in part was underlaid by a coal bed or beds of workable size and of commercial value and later, if the prospects were found to be of a promising nature, to have the property carefully and thoroughly developed.

Reconnoissances on foot and on horseback revealed the fact that the country, under investigation, was clothed with a growth of magnificent virgin timber, while the hill and mountain sides presented a dense undergrowth of sprouts, bushes and briers, growing from a soil that was covered by loose rocks of all sizes, from the pebble to the large boulder, while "the wash" overlying the coal beds was heavy and frequently found to be more like concrete than "the wash" ordinarily found; furthermore, it contained, in addition to the usual sized rocks,

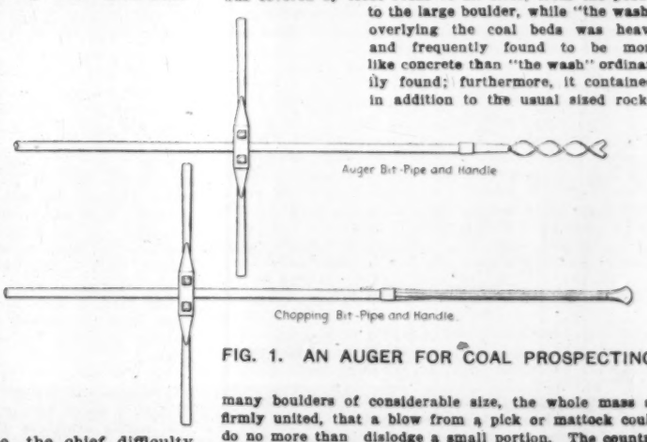


FIG. 1. AN AUGER FOR COAL PROSPECTING.

many boulders of considerable size, the whole mass so firmly united, that a blow from a pick or mattock could do no more than dislodge a small portion. The country was sparsely settled, its roads were poor and the nearest point of the railroad was some seventeen miles away.

The work was begun on an outcrop which was, by actual survey, traced for over 65 miles, and its coal tested in 27 drifts, each driven in never less than 25 ft. under top rock (not merely under cover). Before the work had progressed very far, it was found that but few cleared spaces would be encountered and that along much of the line, because of the dense undergrowth, an unobstructed view along the outcrop was not to be had; the progress of the men in going from the hole drilled to the next proposed location was much impeded. In order to obviate this, an axeman was started ahead while the drilling was going on, to clear a path along the supposed line of outcrop. Neither terrace nor any other topographic feature was present to aid us. After several hundred feet of drilling along the outcrop had been accomplished and the rate of rise or fall of the bottom of the bed had been approximately determined, the axeman was kept close to the line by means of a hand level. It was seldom that a sight ahead longer than 50 ft. could be had, prior to the clearing away of the brush.

The total area developed exceeded 50 sq. miles and the area underlaid by this bed approximates 10,000 acres. As the work was not pursued continuously, the exact time required to perform it cannot at this time be accurately given. The work was at times carried on at zero temperature. A small fire was kindled, and if snow lay on the ground it was melted in a bucket to supply not only water, but hot water, which enabled us to drill through frozen ground without difficulty, and at the

*Abstract of a paper presented at the Roanoke meeting of the Appalachian Engineering Association, May 8, 1909.

†Pottsville, Pa.

same time the necessity of making long trips down to the streams was done away with. Neither drilling nor drift driving were interfered with by even excessively cold weather. Sleet and rain did, however, interfere, and at such times the men were set to driving drifts.

These facts are given to show that a thorough test was made of the drilling auger and accessories which are about to be described.

DESCRIPTION OF AUGER.—For a number of years prior to the beginning of the work referred to, the usual methods of prospecting, by trenching and drilling with a hand churn drill, were by no means satisfactory to the writer. To all the large drill manufacturers, letters were written asking for information regarding a tool which would meet the requirements. To each letter an answer was received, stating that no such tool was made; neither had they ever heard of one. In metal prospecting in the far West, a drill auger, resembling the one to be described, had been sometimes used. Of this I obtained a description, and, after modifying and improving upon both the form of auger and handle, sent drawings to several shops, and from them the tools were made. As the work progressed, such changes were made as were found to be improvements upon the originals. In its present form it has given the greatest satisfaction, and no trouble from breakage, or, in fact, of any kind has been experienced.

The tool consists essentially of four parts: a heavy auger, a handle, a cutting bit and a number of sections of 1-in. gas pipe (one 8 ft., the others 3 ft. in length), threaded at both ends and fitted with ferrules. The auger is made of ½-in. steel, four turns in 18 ins. with the shank

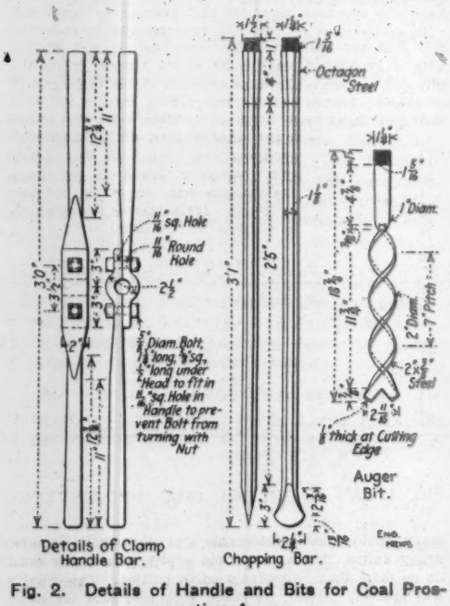

Octagon Steel
1" Diam.
2" Diam.
7" Pitch
2½" x ½" Steel
⅛" thick at Cutting Edge
Auger Bit.
Diam. Bolt, ½ Sq., ½" long under Head to fit in ½" Sq. Hole in Handle to prevent Bolt from turning with Nut
Details of Clamp Handle Bar.
Chopping Bar.

Fig. 2. Details of Handle and Bits for Coal Prospecting Auger.

rounded, and threaded to fit the ferrule, and to this are screwed the sections of pipe as the depth of the hole increases. It has been found well to have the first section made longer than the others, as the handle can be passed up and down as required, without entirely uncoupling it, as becomes necessary when passing over a ferrule. The handle is made in two sections, as shown in Fig. 2. The joining ends are held firmly by two bolts and a circular hole drilled of a diameter slightly less than that of the pipe. With the bolts tightened up fully, the pipe will twist before the handle will slip around the pipe.

For holes exceeding 10 ft., when loose rock is encountered, a cutting bit (see drawings) replaces the auger until the obstruction is passed through. It has been found that greater speed can be made by using ordinary jumpers and an 8-lb. striking hammer for holes wherein obstructions are met at a depth of less than 10 and more than 4 ft. The jumpers are made of 1⅛-in. octagon steel of good quality. The bits are of the round rather than triangular shape. Two of these are usually carried with the party, one 6 ft. and the other 10 ft. long. The accompanying detail working drawing (Fig. 2) fully explains the form of each of the parts, and, the dimensions being given, the whole outfit can be made should any desire to have one. Any good colliery blacksmith should be able to make one, at a cost not to exceed $15.

The outfit, complete, includes two auger bits (one for any emergency, although but two or three were broken in drilling the 65 miles outcrop), a cutting bit, two jumpers 6 and 10 ft. long, one-half dozen 18-in. bastard files for sharpening the blades of the auger, an 8-lb. striking hammer, an 18-in. pipe wrench, a monkey wrench for loosening the bolts in handle, a galvanized iron bucket and tin cup, a mattock and short-handle shovel, an oil cadger filled with lubricating oil for use on ferrules and pipes, and a short-handle cutting axe. The entire outfit can be carried readily by a party of three men almost anywhere; in fact, where the holes are not far apart two men, by making an extra trip, can transport them. It has been found advantageous, however, to use three rather than two men to a crew, as three can work to far better advantage, and the difference in cost is more than made up by the increased amount of work accomplished.

METHODS OF PROSPECTING.—Let us assume, for example, that a commercially valuable bed of coal had been found and it is desired to trace its line of outcrop throughout the property, method of procedure would be as follows: if the general dip of the measures was unknown, and no surface signs visible, a short distance, say 100 to 200 ft. from opening, or nearly the same level as the top of the bed exposed, a hole should be drilled. If this point be on the slope of a hill, a space of say 2½ to 3 ft. square, should be leveled off with a mattock and spade. This gives the men firm foothold. The auger, attached to an 8-ft. section of pipe to which the handle is securely attached, is put down and the handle turned until the auger has cut through 7 or 8 ins. of "wash"; it is then removed and a cup or two of water is poured into the hole and drilling is resumed, the purpose of the water, if the ground be very dry, is to dampen the soil, but do not make it too wet. The material cut through will then cling to the auger, filling the grooves, and the whole can be quickly removed when the auger is withdrawn. After each drawing up of the auger a small quantity of water is introduced.

The advantage of the auger over the churn drill is here exhibited, for with the auger neither a scraper, swab stick or sand pump is required, while with the churn drill the whole mass must be made pasty, so that it can be drawn up with swab stick or in a sand pump. Another advantage the auger has is that the sides of the hole become packed hard, and no difficulty is experienced from caving in. The holes drilled with it, if covered, remain open for many months. The sand pump was used only in extremely wet holes, and generally it was only necessary to use it when holes were drilled near water level. Throughout this entire work the sand pump was resorted to but in a few instances.

Now suppose a boulder or rock was encountered when a depth of 4 or 5 ft. had been reached; the auger would be removed and the 6-ft. jumper put in and a hole driven through the rock with the aid of the striking hammer. How was it possible to know that it was only a boulder and not a solid ledge of rock that had been struck? The sense of touch determines this, for if a boulder, there is seemingly a giving away feeling which is not experienced when a solid ledge is struck. Rocks 18 ins. thick or more have been cut through, and, after some little experience, the men can quickly decide whether the rock encountered is a floater or a solid ledge.

The rock being cut through, the auger is again put into service and the drilling continues. As each 12 or 18 ins. is bored through the drill is brought up and the cutting examined for signs of coal blossom. If any be found, the auger is returned to the hole and a mark made on the pipe on a level with the top of the hole. It is then withdrawn and the distance (from the end of the bit to the mark on the pipe) measured; the auger is again returned and boring resumed until, as detected by the sense of touch, some other material, such as shale or slate, is penetrated. When this occurs, the pipe is again marked as before and the material is bored through, when another mark is placed and the auger is raised sufficiently to measure the distance between the marks. In this way the thickness of the slate or shale can be rather accurately determined. It requires but a short experience to learn the difference between coal, bone, shale, slate and fire clay through sense of touch. This was proven by noting the record obtained with the drill and comparing it later with the record taken when a drift was driven in later at the same place. The difference in the records was hardly appreciable. While it is not necessary to drill entirely through the entire seam in each hole (a few feet generally is sufficient), at intervals of about every 800 to a 1,000 ft., it is well to get as near to the edge of the top rock as possible and drill entirely through the seam.

As the blades of the auger may become dull after 20 to 30 ft. of soil, coal and shale have been cut through, these are filed up and made sharp again without removing the auger from the pipe. Should the drill become fast in the hole, a few reversed turns will most likely free it and it can be drawn up with but little effort. If difficulty be encountered, the 10-ft. jumper can be used as a bar, placing it beneath the handle and with one end on a stone a short distance up the hill. In all the work described above, not an auger was lost. A pipe wrench can be used to advantage in uncoupling the sections of pipe, and the method used was to place the drill on the ground with handle held down by one man, while the other uncouples the sections with the pipe wrench. If oil be used on the threads, but little difficulty will be experienced in detaching the sections.

As all know, who have had experience, the blossom tails out as it approaches the surface, and it is well to drill several holes on it in a line at right angles to the line of outcrop, for when the holes are 1,000 or 1,500 ft. apart and not in sight of each other it would be possible to get either too high or too low, and where beds are only 20 to 40 ft. apart, as it sometimes happens, it might be possible to mistake one for the other. Of course, if a section of the entire bed is drilled through, as suggested above, the error would be quickly discovered; hence it is advisable that this precaution be taken.

The best record made in this concrete-like "wash," including the drilling through a boulder, was 10 ft. in 70 minutes. In ordinary "wash," of course, greater progress could be made. With the exercise of ordinary care and attention, excellent records, not only of the thickness of the bed itself, but likewise of the character of the material penetrated, can be secured. Experience has demonstrated that it is unsafe frequently to value a bed or take from it a sample for analysis until the face of the drift is 25 to 30 ft. under rock cover. Of course, there are exceptions to this rule, and a bed with top and bottom rock in place, especially where the hill slopes abruptly, may show its composition when but a few feet under rock cover; it is safer, however, to get farther in, especially if a sample for analysis is to be secured.

No more thorough method could probably be devised, and, in the matter of cost, it is very much less than the old method of trenching and shafting. If a line of holes along the entire outcrop be not desired (nor is it necessary where, for instance, a well-defined terrace exists), the terrace can be followed and holes drilled at intervals of 2,500 to 3,000 ft., and equally good results be obtained if care be taken; but in territory where neither terraces, ledges or the average dip of the seam are known, it is believed to be safer to drill the holes at distances not greater than 500 ft. or less. The contrivance not only permits the tracing to be done more expeditiously, but very much more cheaply and more thoroughly than is possible by other methods of prospecting. It is not possible for three men to sink a shaft 6 × 10 ft. in 70 minutes, and while it is not intended to convey the idea that an auger hole record is as accurate as an actual measurement of the coal bed, when uncovered, the difference is so slight, if care be taken with the measurements and examinations of the cuttings as they are removed, as to be almost inappreciable.

Notes from Engineering Schools.

UNIVERSITY OF ILLINOIS.—The new laboratory of physics, for the building and equipment of which the State of Illinois appropriated $250,000, was dedicated on Nov. 26. The new laboratory is a fireproof three-story building, with basement and attic. The architecture is simple but imposing, and the building is a notable addition to the engineering group. It stands between Engineering Hall and the Chemistry Building. The trustees of the university have approved the State Architect's plans for a new building, for general classroom purposes, to cost, $250,000, which was appropriated at last session of the Legislature.

COLUMBIA UNIVERSITY.—The demand for competent teachers of industrial arts has led the faculty of the Teachers' College of Columbia University, New York City, to plan a series of night courses, by which young men who have good technical ability in the trades, such as wood and metal working, can prepare themselves as teachers of such work. Courses are being offered, at night, in the School of Industrial Arts of the Teachers' College, covering mathematics, drafting, design, woodworking, machine-shop practice, industrial chemistry, industrial history, methods of teaching industrial arts. A three years' course of night work will enable an expert mechanic, otherwise qualified, to gain a diploma as teacher of industrial arts.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—Through an anonymous contribution, a 40-ft. model of the U. S. S. "Manning" is being built in the shipyard of Stearns and McKay at Marblehead, Mass., for tests by the Naval Architecture Department of the Institute. It will be driven by a gasoline-electric generating set and a motor. The "Manning" was chosen because of data already at hand on a series of progres-

sive speed trials made in 1899 and reported to the Society of Naval Architects and Marine Engineers. It is expected to obtain more light on the relation between the characteristics of a full sized ship and of its model. After tests of the model, as a true miniature, have been completed, various forms and locations of propellers will be tried and changes will be made on the hull. This new equipment will be used during the coming summer by Prof. C. H. Peabody and his associates for original research.

RENSSELAER POLYTECHNIC INSTITUTE.—A testing flume for the calibration of water meters and other experiments, just installed in the Mechanical Engineering department, is 95 ft. long and is equipped with a moving car to carry the meter. Electrical recording devices are attached so that records may be made of distance, time and revolutions of the meter. The flume was presented by W. & L. E. Gurley, of Troy, N. Y.

A new Cement Testing Laboratory has just been completed in the department for the tests of materials. Each table is completely equipped with moist boxes, screens, scales, molds, and other necessary apparatus. Prof. Lawson of this department has recently devised and installed an automatic motor-driven cement sifting shaker which is doing very satisfactory work. In the same department there has just been installed a four-cylinder Deval abrasion machine and a standard impact machine, both direct-connected motor driven, for testing road metals. There is also a direct-connected motor driven standard rattler for abrasion tests of paving bricks and other materials, a heating oven, and tanks for absorption tests. A White-Souther endurance machine for the testing of fatigue of metals has also been recently installed. This device is belted to an electric motor which rotates the test specimen at a high speed and produces a reversal of stress in the specimen at each revolution, thus allowing millions of stress reversals on a specimen.

A FIRE IN A MINE FAN HOUSE near Johnstown, Pa., Dec. 10, caused the suffocation of three miners. Smoke from the burning fan house was blown into the mine by the fan.

A COAL MINE EXPLOSION at Henderson, Ky., in the Baker mine of the West Kentucky Coal Co., Dec. 11, imprisoned six negro miners. The fire which followed the explosion was extinguished Dec. 13 by flooding the mine. It is presumed that the six miners have perished.

A POWDER MILL EXPLOSION at Falls Junction, Ohio, Dec. 10, destroyed the press mill of the Austin Powder Co. and killed three workmen. Three tons of blasting powder exploded.

A CONFLAGRATION AT KALAMAZOO, MICH., Dec. 8-9, destroyed a dozen buildings in the business section of the city, causing a loss to property estimated at $750,000. The local fire department was assisted by firemen from Battle Creek and Grand Rapids. The extent of the fire is attributed to the inadequacy of the water-supply.

A SEVERE STORM ON LAKE ERIE, Dec. 8-9, caused the loss of the steamships "Clarion" and "W. C. Richardson" and the Marquette & Bessemer car ferry No. 2. The total loss of life on these three vessels was 58. The steamship "Josiah G. Munro" ran aground in attempting the rescue of sailors from the "Clarion," which was destroyed by fire.

THE CONTENTS OF A TAR VAT BURNED Dec. 11 at the roofing plant of the McClintock & Irvine Co. in Pittsburg, Pa. In some unexplained manner the valve of the vat was opened and the tar ran out and caught fire. Three men sleeping near the vat were caught in the tar, and two, being unable to extricate themselves, were burned to death.

AN EXPLOSION OF OXY-ACETYLENE WELDING apparatus at Philadelphia, Pa., Dec. 7, wrecked a part of the factory of the Stiffel & Freeman Safe Manufacturing Co. at Second and Somerset Sts., and portions of two adjoining buildings. One man was killed and another badly injured. The installation of the oxy-acetylene apparatus in the safe company's building was just being completed by the two victims of the accident at the time it took place. The exact nature of the explosion has not been ascertained.

A REAR COLLISION between a train running as the second section of the "20th Century Limited" and passenger train No. 10, both eastbound, took place Dec. 13 at midnight on the Lake Shore & Michigan Southern Ry. at North East, Pa. Three passengers were killed and seven others were injured. Train No. 10, known as the Boston and New York special, was stopped by the block signals behind train No. 12, which in turn had been stopped by train No. 6 which was stalled near North East with a broken engine. The St. Louis section of the "20th Century Limited" was a few minutes late and running to make up time. Her engineer apparently did not see the block signal lights nor the lantern of a brakeman who had been sent back from No. 10, for he applied the brakes only when almost upon the train ahead. The smoking car of No. 10 was completely wrecked and a few other cars on the same train were less seriously damaged. All of those killed and injured were in the wrecked smoking car. Not even the locomotive of the limited was very much damaged and it was able to finish the trip to New York as soon as the track was cleared.

THE WATER-SUPPLY TUNNEL WORK UNDER New York City, described in our issue of Dec. 9, 1909, p. 632, has been approved by the Board of Estimate and Apportionment.

AN AUTOMATIC SIGNAL FOR ELECTRIC RAILways was tested Dec. 2 on one of the trolley lines in Newark, N. J. The system used was similar to that in common use to operate semaphore block signals on steam railways. The signal is intended primarily for single-track lines between turnout switches, and one signal unit is placed at each end of the stretch of single track to be protected. The signal is visible to the motorman as his car is about to pass from the turnout to the single track and gives him an indication of the presence of cars on the single line between him and the next passing point.

Three indications were arranged for: a red light indicated that there was a car approaching on the single track, a green light indicated that the block was occupied by a car that was running in the same direction as that to which the signal was shown, a yellow light showed that the track between turnouts was unoccupied. The three lights with their colored bulls-eyes were arranged one above another in a metal case attached to one of the poles at the side of the track. The box containing the operating mechanism was fastened to the pole at its base so as to be easily accessible.

The controller switch was of the counting type. Ratchet wheels mounted on the shaft which moved the switch finger across the face of the contact segment were moved by pawls actuated by electromagnets. One pawl and ratchet wheel turned the shaft in one direction and the other in the opposite direction. When a car entered the block, the switch finger was turned onto the segment by the amount of one ratchet tooth. Each successive car entering the block in the same direction caused the finger to move further by one notch across the segment but this did not affect the connection and the light remained green. As the cars went out at the further end of the block, the second pawl and ratchet wheel came into operation, and for each car the switch finger was moved back one notch toward the point of release. Thus the signal light remained green until the last car had passed out of the block. Current for the operation of the controller switch and for the lights was taken from the trolley circuit.

The relays were of the type regularly used in the block signal systems of steam railways and current for the relay circuit was furnished by two Gordon cells. The Gordon cell has copper-oxide and zinc electrodes in a solution of caustic soda and may be operated on either open or closed circuits. One relay governed the setting ratchet and the other the releasing ratchet of the controller switch. Two consecutive rails on the same side of the single track immediately adjoining each turnout were insulated from each other and from the adjacent rails by three Webber insulated joints with ½-in. of fiber between rail ends. The insulated rail nearer the turnout was connected to one terminal of the setting-relay circuit and the second insulated rail was connected to one terminal of the releasing-relay circuit. The other relay terminals were grounded. To complete the track circuit around the insulated rails, an extra rail was laid in the middle of the track and connected at its ends by copper bonds to the ends of the rails adjacent to the insulated ones. This central rail was buried in the earth filling between the rails.

When the signal was set by a car entering the block, the two insulated rails were at the same time connected by the relay into one circuit so that the release was not operated until the car reached the second release rail at the further end of the block. Similarly the resetting of the signal as the car passed over the further setting rail in leaving the block was prevented.

According to Mr. J. J. Cozzens, Chief Engineer of the Kinsman Block System Co., which is putting this signal on the market, no trouble was experienced with the trial installation during or after a heavy rain, and it was also stated that the signal could not be operated by the tires of wagons, even when driven in such a way that the tires scraped along the side of the rail.

CHICAGO STREET LIGHTING.—The Chicago City Council, on Nov. 22, asked for negotiations with the trustees of the Sanitary District for the lighting of the entire city by electric current from the hydro-electric plant on the Drainage Canal at Lockport. (This project was outlined in Engineering News, Jan. 12, 1905, and the construction of the 26,000-HP. hydro-electric plant was described Jan. 18, 1906.) The present street lighting is by a municipal system of old series, open-arc lamps fed from the old plants which were converted from steam to electric-motor drive a few years ago. The current for the old plants comes from the Drainage Canal station. It is desired to replace the old arc lamps, to install 17,000 new ones, and to run them all from alternating-current transformer substations. The cost of the desired change is placed at $2,500,000.

Mr. R. R. McCormick, President of the Drainage Board, has recommended that the organization of the sanitary district

purchase from the City of Chicago the 12,000-volt transmission lines necessary to bring the current to the city substations; that the sanitary district purchase the substations and electrical equipment therein and contract to supply current to the city circuits at the present price, plus an agreed charge to cover the cost of transmission and delivery of current upon the arc system of the city.

In addition, Mr. McCormick recommends the substitution of electric drives at the various pumping stations, using current day times from the machines that would supply the street lighting at night. A rate of $15 per HP.-year is charged for lighting power, and this would be increased to only $26.40 for a continuous supply. For times when the pumping and lighting loads coincide Mr. McCormick recommends the operation of the most efficient of the steam plants.

PLATINUM IN THE UNITED STATES.—A report by Mr. D. T. Day, published as an advance chapter of "Mineral Resources of the United States, 1908," discusses the greatest platinum deposits of the world, the metallurgy and use of the metal. From this it appears that platinum is produced in the United States only as a by-product in placer-gold mining in Oregon and California. The output in 1908 was 750 troy ounces, valued at $14,250. This quantity was nearly double that produced in 1907, but the value of the product was only about 35% greater, owing to a decline in prices. During the last three years the price has fluctuated from $18.20 to $38 per troy ounce for refined metal (the value of gold is about $20.67 per troy ounce) and the amount of crude platinum or platinum ore annually imported into the United States, chiefly from Russia, has ranged from 4,237 lbs., valued at $1,095,754, to 11,494 lbs., valued at $3,601,120.

The first use of platinum was for chemical vessels, on account of its great resistance to most chemical actions. During recent years it has found increasing use in the manufacture of jewelry. A small amount is used in each incandescent electric lamp now manufactured. It is here used, as the "leading-in" conductor of the glass bulb, on account of its thermal coefficient of expansion, which is nearly the same as for glass. Platinum also has an increasing use in dentistry and for the ignition plugs of internal-combustion engines.

One of the important industrial uses of platinum is in the sulphuric-acid industry. More than half of the sulphuric acid now made is manufactured by the use of platinum.

ONE AMERICAN SHIP THROUGH THE SUEZ CANAL is the record for 1908. This was a trading vessel of 626 registered tons. The record does not include warships, colliers or transports of the United States Government. In our issue of June 17, 1909, p. 675, we gave the total statistics for 1908 of tonnage passing through the Suez Canal, but below we give some detailed figures, taken from the U. S. Consular Reports, showing the vessels passing through the canal, giving the United States either as ports of origin or destination:

	Registered tonnage.
FROM U. S.	
60—British flag	246,068
21—British flag (from U. S. possessions)	56,163
1—French flag	3,074
30—German flag	94,354
3—German flag (from U. S. possessions)	7,520
3—Japanese flag	9,010
1—Norwegian flag	2,489
13—Spanish flag (from U. S. possessions)	31,390
TO U. S.	
135—British flag	390,678
5—British flag (to U. S. possessions)	14,519
3—Austro-Hungarian flag	9,063
3—French flag	12,046
32—German flag	104,805
1—Japanese flag	2,904
13—Spanish flag (to U. S. possessions)	30,328

Of the vessels giving United States ports as ports of destination, 14 were for Boston, 87 for New York, 11 for Philadelphia, 44 for Delaware Bay, 2 for New Orleans,

1 for Port Arthur, Tex., 1 for Galveston, 1 for San Francisco, 1 for Portland, 1 for Seattle, 10 for Manila, 8 for Iloilo, and 2 for other Philippine ports. Six American warships passed through the canal in 1908 and 4 in 1907.

COST OF OPERATING MOTOR OMNIBUSES, run by the Wolverhampton Corporation (England) in connection with its tramway lines, is disclosed in a report on the operation for the year 1908-9. The figures are summarized below, from the London "Electrician" of Nov. 19. The total mileage was 54,788:

			Per vehicle mile	
Operating Expenses:				
Petrol	£412	$1,975.00	1.806d.	3.612 cts.
Wages of drivers etc	565	2,710.00	2.476d.	4.952 "
Wages of cleaners, etc.	86	413.00	0.378d.	0.756 "
Oil, grease, etc.	49	235.00	0.213d.	0.426 "
Lighting omnibuses.	44	211.00	0.193d.	0.386 "
Tickets, etc.	5	24.00	0.023d.	0.046 "
Uniforms	20	96.00	0.089d.	0.178 "
Miscellaneous	1	4.80	0.001d.	0.002 "
Total operating costs	£1,182	$5,668.80	5.179d.	10.358 cts.
General Charges:				
Licences	£13	$62.40	0.059d.	0.118 cts.
Insurances	103	494.00	0.450d.	0.900 "
Total gen. charges.	£116	$556.40	0.509d	1.018 cts.
Maintenance, Repairs, etc:				
Tires	£531	$2,550.00	2.327d.	4.654 cts.
Rolling stock	437	2,100.00	1.913d.	3.826 "
Depreciation	483	2,320.00	2.116d.	4,232 "
Bankers' interest..	37	177.50	0.162d.	0.324 "
Total repairs	£1,488	$7,147.50	6.518d.	13.036 cts.
Total expenses	£2,786	$13,372.70	12.206d.	24.412 cts.

The revenue was £2,704 ($12,979) or 11.844d (23.688 cts.) per vehicle mile. It should be noted that these figures include no management expenses, rents, etc., as these were all charged to the railway accounts.

Personals.

Mr. J. C. S. Blackburn, of Versailles, Ky., has resigned his position as a member of the Isthmian Canal Commission. Mr. Blackburn had been a member of the commission since April 1, 1907.

Mr. Geo. B. Johnson has been appointed Joint Division Superintendent of the Texas & Pacific Ry. and the Missouri, Kansas & Texas Ry. at Ft. Worth, Tex., to succeed Mr. W. S. Polhemus, resigned.

Mr. Michael Hassett has been appointed Master Mechanic of the New York Central & Hudson River R. R. at East Buffalo, N. Y., to succeed Mr. F. M. Steele, who has been transferred to Rochester, N. Y.

Mr. Emil Swensson, Vice-President Am. Soc. C. E., has been appointed by the Pennsylvania State Railway Commission to report as to the Pittsburg Railways Co.'s fulfillment of the commision's recommendations.

Mr. E. D. Stearns has been appointed Manager of the Stephens-Adamson Co., of New York City, with which he has been associated for the past three years in the manufacture of conveying, transmission and screening machinery.

Mr. Wm. Lowe Brown, M. Am. Soc. C. E., recently Resident Engineer of the North River tunnels of the Pennsylvania Tunnel & Terminal R. R. Co., has been appointed Engineer of the underground extension in Buenos Aires of the Buenos Aires Western Ry.

Mr. Walter G. Clark, Assoc. Am. Inst. E. E., has retired from the presidency of the Parker Clark Electric Co., New York City, and has been succeeded by Mr. Geo. N. Miller. The offices of the company have been removed from the Singer Bldg. to the Lincoln Square Bldg., 1966 Broadway.

Mr. M. H. Hovey, recently Superintendent of Construction for the American Railway Signal Co. at Cleveland, Ohio, has been appointed to serve as an expert on signaling on the joint engineering staff of the Railroad Commission of Wisconsin and the Wisconsin Tax Commission. Mr. Hovey was formerly a signaling expert in the service of the Federal Block Signaling and Train Safety Board and will resume his former duties with that board in connection with his work for the Wisconsin commissions. His headquarters after Jan. 1 will be at Madison, Wis.

Mr. W. S. Tinsman, formerly Manager of the Southern and Choctaw divisions of the Chicago, Rock Island & Pacific Ry., has become Vice-President and General Manager, and has made the following appointments: Mr. W. M. Whitenton, General Superintendent of the Choctaw district has been appointed to succeed Mr. Tinsman as Manager at El Reno, Okla.; Mr. T. H. Beacom, Division Superintendent at Trenton, Mo., will succeed Mr. Whitenton as General Superintendent at Little Rock, Ark.; Mr. F. J. Easley, Division Superintendent at Little Rock, will succeed Mr. Beacom as Division Superintendent at Trenton, Mo.; Mr. A. B. Copley will succeed Mr. Easley as Superintendent of the Arkansas division at Little Rock; Mr. D. Coughlin will succeed Mr. Copley as Division Superintendent at Halleyville, Okla. Mr. C. W. Jones, General Superintendent at Topeka, Kan., has been transferred to Davenport, Iowa; Mr. J. B. Smalley, Division Superintendent at Rock Island, Ill., has been appointed to succeed Mr. Jones as General Superintendent at Topeka; Mr. H. P. Greenough will succeed Mr. Smalley as Division Superintendent at Rock Island; Mr. A. T. Abbott will succeed Mr. Greenough as Division Superintendent at Des Moines, Iowa; Mr. F. M. Patt will succeed Mr. Abbott as Superintendent of the Colorado division at Colorado Springs; Mr. A. B. Ramsdell will succeed Mr. Patt as Superintendent of the Chicago terminal.

Obituary.

R. W. B. Dear, a mining contractor and formerly President of the Butte-Balaklava Copper Co., died Dec. 12 at Superior, Wis.

Moses A. True, President of the Central Engineering & Construction Co., Chicago, died of heart disease Dec. 10. He was 53 years old.

W. N. McGugin, President of the McGugin Iron & Coal Co., Olive Furnace, Lawrence Co., Ohio, died at that place Dec. 7 aged 92 years.

Samuel Lefler, an engineering contractor of San Bernardino, Cal., died Nov. 23 at his home in Urbita, Cal. Mr. Lefler was born in Ohio in 1846 and had been a resident of San Bernardino for the past 23 years.

Charles B. Withington, inventor of the automatic grain binder, died Dec. 12 at his residence in Janesville, Wis. Mr. Withington obtained a patent on his automatic binder in 1870 and sold it four years later to Cyrus H. McCormick, of Chicago. For the next 30 years he was associated with the McCormick Co. in the manufacture of agricultural machinery.

Daniel W. Church, Chief Assistant City Engineer of Chicago, Ill., died Dec. 7 at the Alexandria Hotel in that city. Mr. Church was a graduate of the Rennselaer Polytechnic Institute in the class of 1877. He was first associated with the city engineer's office in Chicago in 1893, but resigned after 1½ years to take a position with the Pittsburg Bridge Co. During his connection with that company, he superintended the construction of the Chicago Coliseum. He rejoined the Chicago City engineering department in 1903 and served as Chief Assistant Engineer up to the time of his death. His body was taken to the home of his family in Governeur, N. Y., for burial.

Engineering Societies.

COMING MEETINGS.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27-Jan. 1. Annual meeting at Boston, Mass. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 28-29. Annual meeting at Ames, Iowa. Secy., L. W. Chase, University of Nebraska, Lincoln, Neb.

MONTANA SOCIETY OF ENGINEERS.
Jan. 6-8. Annual meeting at Butte, Mont. Secy., Clinton H. Moore, Butte, Mont.

MICHIGAN ENGINEERING SOCIETY.
Jan. 12-14. Annual meeting at Lansing, Mich. Secy., Alba L. Holmes, 574 Wealthy Ave., Grand Rapids, Mich.

INDIANA ENGINEERING SOCIETY.
Jan. 13-15. Annual convention at Indianapolis, Ind. Secy., Chas. Brossmann, Union Trust Bldg., Indianapolis, Ind.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
Jan. 18-20. Annual meeting at New York City. Secy., W. M. Mackay, P. O. Box 1818, New York City.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 19-20. Annual meeting at New York City. Secy., Chas. W. Hunt, 220 West 57th St., New York City.

AMERICAN SOCIETY OF INSPECTORS OF PLUMBING AND SANITARY ENGINEERS.
Jan. 20-22. Annual convention at Trenton, N. J. Secy., C. S. McCosker, Mobile, Ala.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 25-27. Annual meeting at Ottawa, Ont. Secy., C. H. McLeod, 413 Dorchester St. West, Montreal, Que.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 26-28. Annual meeting at Cairo, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago, Ill.

NATIONAL BRICK MANUFACTURER'S ASSOCIATION.
Feb. 7-12. Annual convention at Pittsburg, Pa. Secy., T. A. Randall, Indianapolis, Ind.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.
Feb. 8. Annual meeting at New Haven, Conn. Secy., J. Frederick Jackson, Box 1204, New Haven, Conn.

BROOKLYN ENGINEERS' CLUB.—At the annual meeting, Dec. 9, officers were elected as follows: President, Geo. A. Orrok; Secretary, Joseph Strachan; Treasurer, Wm. T. Donnelly.

NATIONAL COMMERCIAL GAS ASSOCIATION.—The fifth annual convention was held in New York City Dec. 13-15. The exhibition of gas appliances at Madison Square Garden will be open to the public until Dec. 21.

WASHINGTON SOCIETY OF ENGINEERS.—At the annual meeting in Washington, D. C., Dec. 7 officers were elected as follows: President, Bernard [illegible] Green; Vice-President, John H. Hanna; Secretary, John [illegible] Hoyt; Treasurer, John B. Gordon. The present membership of the society is 283. Following the election of officers, Dr. L. A. Bauer, Director of the department of terrestrial magnetism of Carnegie Institute, gave an illustrated lecture on the ship "Carnegie" now on a cruise in the northern Atlantic Ocean investigating the earth's magnetism.

AMERICAN ASSOCIATION OF REFRIGERATION.—Officers have been elected as follows: Honorary President, Frank D. La Lanne, Philadelphia, Pa.; President, Homer McDaniel, Cleveland, Ohio; Vice-Presidents, E. O. McCormick, Chicago, Ill.; T. O. Vilter, Milwaukee, Wis.; John E. Starr, New York City, and W. J. Rushton, Birmingham, Ala.; Treasurer, John S. Field, Chicago, Ill.; Secretary, J. F. Nickerson, Chicago, Ill. This society is affiliated with the International Association of Refrigeration. At the second International Congress of Refrigeration, which is to be held in Vienna, Austria, Sept. 29-Oct. 3, 1910, five international committees will report, respectively, on the following subjects: Liquefied gases and units; methods of testing refrigerating machinery and insulating material; general application of refrigeration; railway and steamship refrigeration; legislation.

NEW ENGLAND WATER WORKS ASSOCIATION.—Two important committee reports were presented at the monthly meeting of the association, held in Boston on Dec. 8. The first of these was the report of a committee on damages resulting from the diversion of water from users of water for power. Messrs. Chas. T. Main is chairman and Mr. Leonard Metcalf is secretary of this committee. An abstract of the committee's report is given elsewhere in this issue.

Following this report, Mr. Chas. F. Choate, a Boston attorney, reviewed "The Underlying Principles Governing Riparian Water Rights and Diversion Suits." This review was characterized by a member of the association as extremely interesting, and so well expressed that it made the matter appear for the time being, at least, very simple. It did not seem as though there was a superfluous word in his remarks.

In discussing Mr. Choate's remarks, Mr. Metcalf asked a few questions with regard to the status of "compensation in kind" in lieu of money damages, and what the conditions would be where water diverted for a public water supply was afterwards returned to the stream in the form of sewage, at a point above the water power privilege claiming damages. In reply, Mr. Choate stated that the courts had refused to recognize any form of compensation except the payment of money damages, and that he felt that any owner of water-power was entitled to refuse to accept sewage in place of comparatively pure water for generating his power; but that he felt it probable that where the sewage was adequately purified by filtration, or otherwise, the courts would hold that in such a case no damage had been suffered, but he knew of no such case which had actually come before the courts. Two or three members referred to cases where compensation in kind had been attempted but the courts had refused to sanction it.

Professor H. K. Barrows called attention to the fact that the Sudbury, Nashua and Croton rivers only had been quoted for run-off records, and that conditions were frequently very different, as in the case of streams in northern Maine.

There was but little other discussion of this report, as the members present apparently felt that the report covered the subject so fully that there was little more to say.

The second committee report presented at this meeting was "On the Depth of Laying Water Pipe." Mr. F. A. Barbour is chairman of the committee that collected information on this subject and presented it in both tabular and graphical form, with textual conclusions. The information included statements regarding pipe-laying practice in some ninety widely distributed cities, and experiences with frozen water in pipes in 53 cities. An abstract of the paper will be given in one of our later issues.

Like the other report, this one elicited but little discussion, presumably for the same general reason. The feeling was evident that even though the results are, as the committee puts it, largely negative, a very valuable work has been done in collecting the information and making it available for reference.

The attendance at the meeting was about 110 to 120 and it seemed to be the universal opinion that it was one of the most interesting meetings which the association has had for a long time.

A special meeting of the association will be held in Hartford on the second Wednesday in April. This is expected to be in all respects similar to one of the regular monthly meetings, except in the place of the meeting. The object of this change is to make it feasible for a considerable number of members to attend who do not find it feasible to get to the Boston meetings, as well as to excite a greater interest in the association in the vicinity of Hartford.